MACHINERY.

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BOILER REFORM.

JOHN J. HOGAN.

THAT a general demand is expressed for some kind of reform or improvement in steam boilers for land, locomotive and marine purposes, is universally admitted. The reason for this call for reform or improvement is found in the fact that every boiler in existence carries with it various and numerous apparent and admitted defects. The defects are divisible into three kinds, viz.: defects of design, defects of construction, and defects of material. Defects of design are probably more numerous than the others.

An intimate knowledge of these defects should tend to have them omitted in future designs. In nearly all boiler designs very little attention or respect has been paid to the natural laws. Many of the disastrous explosions would not have occurred if natural laws had been observed in the design of steam boilers. The mere addition of material increases rather than reduces the defects, especially when there is no change in the design of land boilers, which formerly used 45 pounds, and are now strained to a working pressure of 125 to 150 pounds per square inch. The same remark may be applied to locomotive and Scotch marine boilers in their increase of pressure to 180 and 200 pounds. The general run of water-tube boilers on land have not even had any additional material, it being the claim of some makers that boilers which formerly run at 100 pounds pressure are now working at 300 pounds pressure per square inch. In all these boilers it may be said the safe working pressure limit of 150 to 250 pounds pressure has been reached if not passed.

John J Hogan

For more safety with these pressures and for higher pressures, some change in design will have to take place and in the new designs the natural laws relating to the absorption and emission of heat will have to be recognized and followed. It is not untrue to say that the greater number of steam boilers in use to-day are little better than makeshifts composed of tubes, drums, boxes held together with stays, of all kinds of forms and each form regardless of the effect of heat on the material, the effect of heat on the water, and the effect of the application of heat at varying temperatures on the material and on the water. All these important points have been passed over without a thought, by the vast majority of boiler idealists who have taken it into their heads that they had conceived the idea of a boiler design in a package or gathering together of a lot of drums, tubes, boxes and stays composed of iron or steel.

To point out the direction in which reform in boilers is needed, it will be best to pass in review the defects and errors which exist and are apparent in the commonest types of construction. The continued use of defective designs, and it might be said their adoption in general practice during the last thirty years, is not a logical reason for their continuance. If it is shown that these defects are in violation of the natural laws and that boilers can be constructed without such defects, it is not right or for the good of the public safety to continue their use in future boilers, and more especially in boilers designed for high pressure.

One of the most common errors in all designs of boilers is the relative location of the fire or grate to the surfaces composing the parts which contain the water. To place a fire at one end under the outside of a drum or shell filled with water, from 36 inches to 72 inches in diameter, and from 10 feet to 30 feet in length, is certainly not an arrangement in accordance with natural laws so far as the effect of heat on the material or water is concerned. This is the condition of design which is found in what are known as "horizontal tubular boilers." The rapid application of heat in these boilers, when the water is cold, produces irregular strains which result in general leakages at the seams and burning of plates and of rivet heads. The continuous application of heat in forced firing produces similar results. The cause of these results is the fact that the material conducts heat so quickly that the water against the heated surfaces is converted into steam more rapidly than the steam can escape in order to permit its replacement by water. Fires placed in flue tubes of diameters from 21 to 44 inches, as in Lancashire, Cornish and Scotch marine boilers, also produce irregular strains and leakages. Corrugated flue tubes, as well as arranging the stays on end plates of shells to allow a give-and-take motion, are among the makeshifts in design and construction to allow for these irregular strains which exist under all conditions of the application of heat to a relative extent. The location of the fire in a locomotive boiler is such as to start strains from the time of the first fire. The inside box or fire box being rigidly stayed or fastened to an outside casing or box, the plates in the two boxes, that is, the inside and outside ones, are always at different temperatures. The same remarks are applicable to the combustion chambers in Scotch marine boilers, the plates forming these chambers being rigidly held by short stay-bolts to the circular plates of the outside shell plates and to the end plate of the shell or the back plates of the two combustion chambers when the boilers are double-ended.

The relative location of the fire and surfaces in horizontally inclined straight water tube boilers does not differ much from the older forms just described. In horizontally inclined tube types of boiler, the fire is placed beneath the highest part of the tubes, and extends under them about one-third of the length. The water in these boilers may be heated more rapidly from

its normal temperature than in the five types of boilers mentioned in the preceding paragraphs. On this account the material is more uniformly heated than in the others. When, however, the water is sufficiently heated to produce steam, the conditions in the seven types of boilers are the same when the application of the heat is continued, steam is produced more rapidly than it can escape, steam globules are formed continuously in the tubes with the result of burning the tubes.

The boiler known as the "Belleville" is another type of horizontally inclined straight water tube boiler. The heat of the fire is applied to the whole length of the tubes. It differs from the type of boiler just mentioned, in the fact that the steam as it is produced in the lower tubes has to pass in one direction and then backwards and forwards, through some fifty lineal feet of tubes before the water line or surface is reached. The feed-water being forced at the lower end prevents an exit for the steam at this end.

Assistant Engineer John K. Robinson, in an article in the *Journal of the American Society of Naval Engineers*, on water water tube boilers in French ships, among other remarks referring to the Belleville boiler, states: "The tubes of the lowest row are made very thick, but they wear out very rapidly nevertheless, being bent after fires are lighted under the boilers two or three times." Whence it is correct to conclude that the steam is produced quick enough to retard, if not stop, the entry of the feed-water into these lower tubes, because if water was passing through them they would not become overheated and bent.

A more recent location of the fire in relation to the heating surfaces in inclined straight water-tube boilers, with headers, and feed-water introduced in upper shell, is shown in diagram, Fig. 1. This arrangement is intended for marine purposes. Under such conditions of the application of heat, no tubes, no matter how well made, nor how good their material, can possibly avoid destruction, when some 2,000 to 2,500 degrees of heat are applied to tubes filled with steam, which prevents the entrance of water into them. Of course these tubes burst and will continue to burst, as the service expected of them is entirely in contradiction to natural laws. It is a curious fact that drawings of this design of boiler did not indicate to the United States steam boiler inspectors that such an arrangement could not be used, "without peril to life," and that it was and is "unsafe in its form," and "dangerous." Among eleven reasons urged in favor of the adoption of this boiler, I quote the third: "Absolutely free circulation, enabling any amount of forcing that the fireman is capable of." This is an example of the irrational claims that are made, and it is hoped that this boiler is the last of its kind to be used, as certainly the zenith of erroneous boiler designing has been reached in such a construction. Here are a few points in the design of steam boilers which are all opposed to natural laws. There is no doubt that boilers can be designed without such defects in design and construction, but how can such changes in design be brought about?

Boilers are usually built with a calculated factor of safety of five or six to one. On this supposition, boilers are tested by hydraulic pressure to, say, twice their working pressure, that is, for 200 pounds working steam pressure an hydraulic pressure of 400 pounds per square inch is applied, so that at the test the factor of safety is reduced to three or two and one-half to one. Questions arise at once, does this test give much information—does it do any good or does it do any harm? Would these incorrectly designed boilers have a factor of safety of three to one, or two to one, or would they withstand the 400 pounds when subject to the irregular strains of expansion due to the irregular overheating of the parts? For this reason I have called the calculated factor of safety a supposition. A change in the method of testing may help to some reform in design and construction. It is therefore suggested to test the boiler by hydraulic pressure to, say, 25 per cent. above the worikng steam pressure, that is, for a working pressure of 200 pounds a hydraulic pressure of 250 pounds be applied. After this test subject the boiler to what may be termed a "fire test;" the water in the boiler to be at a temperature of 50 to 60 degrees Fah.; the boiler to be then fired, with oil, gas or wood, so that steam pressure be raised in, say, twenty minutes, and this forced firing to be kept up for several hours, during which time the working pressure will be maintained. If the boiler remains tight and keeps together under this test, it is fit for a high working steam pressure. Should it leak or go apart it may be relegated to the old form of erroneously designed boilers, and not be allowed a higher pressure than, say, 125 pounds.

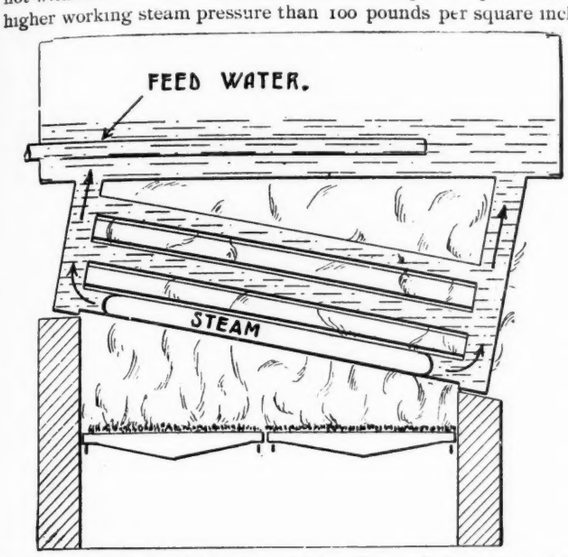
Numerous other defects, or rather makeshifts, necessitated by erroneous designs, exist in steam boilers. Gussets, stays and crowfeet stays from shells to heads are not to be used in well designed boilers. In fact, staying a heated plate to a plate not heated is mechanically incorrect. Again, stay-tubes in Scotch marine boilers do as much harm to the joints of the adjacent tubes as they do good in keeping the end plates from being forced out by the internal pressure. Tubes between rigid tube plates, or between long, stiff headers, whether the latter be of cast iron or steel, are defective in design and construction because the elongation of the tubes when heated is not provided for. To this method of construction is due the leakage at the tube ends and irregular strains on headers. Placing only a small fraction of the heating surfaces over the fire and the greatest portion of it in the second and third return flues is, it may be said, contrary to common sense. It is a well-known fact, one square foot of surface over the fire is more efficient than four square feet in the return flues. The soot readily adheres to surfaces in these return flues, and boilers which require the heating surfaces to be cleaned daily in order to prevent a marked decrease in their efficiency, should not be even discussed, on account of the ridiculousness of the proposition. The spaces above the grate and in which the heated gases give off their heat to the surfaces, should be of large volume and not low as in Scotch marine boilers, and not contracted as in the water-tube boilers. The volume of the gas space should be two or three times greater than the volume of water enclosed within the heating surfaces. In practice this is actually reversed. It might be inferred that boilers generally have been designed more for the purpose of cooling or condensing the gases and preventing combustion than for the purpose of heating the water. The weight of marine boilers can be materially and practically reduced by using fire surfaces rather than surfaces in return flues, because the efficiency of the former is some four times greater than the latter surfaces, especially when the volume of the spaces for the gases is sufficient to maintain them at high temperatures. Another curious feature in the design of Scotch marine and Lancashire boilers is the location of the fire above the water. This arrangement does not even induce the slightest circulation of the water. The water below the fire will remain at 60 or 70 degrees, while the water above the fire may be 300 degrees, when firing up these boilers at first. The difference in the elongation of the upper part and lower part of the shell due to expansion, as well as the severe irregular and unnatural strains, are apparent. The lower body of water is only heated by conduction, and in a relative degree these unnatural strains are in existence at all times while the boiler is fired.

Another law of nature that has generally been lightly passed over, is the fact that the motion of water due to the absorption of heat by the water is a vertical motion. Every inclination or turn from the vertical motion is a hindrance and therefore a loss of force. The motion due to the absorption of heat in one sense produces two vertical motions, one downward and one upward, in two minute columns of molecules of water. This vertical motion is uninterrupted until some surface, inclined or horizontal, changes the the vertical motion, or until the temperatures of the water in the downward and upward motion become equal. The tendency to equalization of the temperatures of downward and upward currents produce what may be termed intermittent currents.

These currents may be at various points in the same vessel or tube. Their intermittency originate the first or original formation of scale, as it permits the adherence to the surface of the foreign matter in the water, which becomes precipitated on account of the increase of temperature. There is scarcely a single steam boiler in existence in which provision is made for the precipitation of the foreign matter entering with the feed-water as this water is raised in temperature. To make this provision distinct, downward currents should exist, and such downward currents cannot exist where heat is applied to the surfaces within which they are stated to exist. This is the condition of nearly all water-tube boilers. For this reason scale forms rapidly on their surfaces, and the feed water cannot be admitted at low temperatures of 40 to 50 degrees Fah., without causing leaks.

A boiler which cannot receive its feed-water supply at less than 100 to 180 degrees is distinctly a boiler not suited for high pressures. If the Board of United States Steam Boiler Inspectors

and Marine Engineers were to require that all boilers should be capable, without injury, of taking in the feed-water at 50 degrees Fah. or less, they would help materially in boiler reform. At present 180 degrees temperature of feed-water is required because the boilers are of such erroneous design that the entrance of a little cold water will cause them to leak and possibly break down. And these boilers are passed as safe for 200 pounds working steam pressure. With the "fire test," already mentioned, the "cold water test" should be also associated, and boilers which do not withstand these tests should not be accepted or permitted a higher working steam pressure than 100 pounds per square inch.



How many boilers exist to-day which will stand these two tests? Very few.

The extent of the surface of the water from which the steam is supposed to escape as rapidly as it is made, is a detail in boiler designing about which many erroneous ideas exist. The extent of this surface should vary in accordance with the quantity of heat absorbed by the water. If the extent of this surface is correct when consuming 12 pounds of coal per square foot of grate, when consuming 24 pounds of coal it should be double, and when consuming 36 pounds of coal it should be three times larger, and so on. For this reason, *i. e.*, the invariableness of the extent of this surface, ebullition causes "priming," and "priming" produces wet steam. To avoid these difficulties the steam as it is produced from small units of surfaces will have to be delivered into the steam space without regard to the water surface. In the steam space, mechanical separation of the water from the steam will be necessary, because the rapid production of steam is not a natural effort, but decidedly an artificial action.

With such an array of defects in steam boilers, it is not surprising that a steam pressure of 175 pounds per square inch is at the limit of safety. Nor is it surprising to hear that the first question asked about a boiler is, How is it to be repaired? It may be said with a good deal of truth that more time has been occupied in arranging for repairs than in dispensing or rejecting actual defects.

One weak argument against reform in boiler design and construction is that the defective forms now existing have been good enough and are good enough. What is relatively equal to something that is bad does not make either in the comparison good. A boiler which deteriorates unless the tubes are scraped with scrapers and picks, can never again give the same working economy as when new, it is therefore of the greatest importance that all boilers should be provided with a means for precipitating all foreign matter through tubes and into vessels, none of which are exposed to the action of the heat. Such provision is found on few boilers at present in use. It has been said that getting steam up quickly is no criterion as to the steaming qualities of the boiler, but this is not exactly correct. But getting steam up quickly without causing leaks or any injury to a boiler is a very strong reason for concluding that the strength of the boiler is not reduced by the application of heat at various temperatures.

The greatest assistance to boiler reform can be given by the United States Marine Engineers requiring high pressure boilers to withstand the tests just proposed, viz., the hydraulic test, the "fire test," the "cold feed-water test," and an examination as to the disposition of the foreign matter in the water in receptacles of relatively low temperatures. A change in some of the rules relating to marine boilers as given out by the Board of Supervising Inspectors of Steam Vessels would relieve the Board of much risk and insure a better class of boilers in vessels generally. Such action on the part of such boilers and steam users generally, would soon cause improvement in the design and construction of steam boilers. The following statements regarding the conditions of boiler design are true, that is, that during the past thirty years there has been no change in design, while more material has been added and material of better quality used. More bolts and scraped joints have been called improvements, otherwise the design of the boilers are the same. The Scotch Marine is the same. The Horizontal Tubular Boiler has not changed. The Horizontally Inclined Water Tube Boilers do not differ. The Lancashire Boiler is without change. The Locomotive Boiler is similar to the first boiler of its kind, and boilers composed of tubes simply consist of an assemblage of tubes, distorted in numerous forms without the slightest regard for the laws of nature or any other principles.

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CUTTING SQUARE THREADED SCREWS.

BOYD HARRIMAN.

Special consideration of common things sometimes awakens novel ideas simply by suggestion. We throw down the facts that we know, and use them as stepping stones to further advance. Therefore, it may be of use, as well as of interest, to some who may be engaged upon a different class of work, to read about common methods of cutting square-threaded screws, although no attempt is made to describe extraordinary proceedings.

The screws herein designated as "square threaded" are not really so, but they are traditionally so termed. The sides of the threads stand at an angle of about 15° with the axis of the screw; hence, if the threads were cut to a full V, the cross section of each thread would be an angle of 30°, speaking after the same manner as we do when we say that the standard V thread is an angle of 60°. This form has descended in these older shops from the original models of half a century ago. The cider mill screws made now might fit the beams originally tapped. The inch screws are about 15°, the sides being inclined about 7½° to the axis. They are for office-chair screws and similar purposes. There is no finical nicety about this work; it is intended for durable service.

Cider mill makers, who in years when there is an ordinary crop

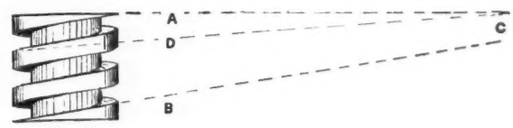

FIG. 4.

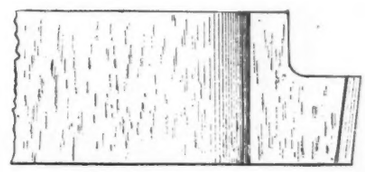

FIG. 3

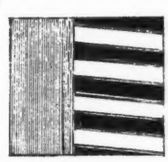

FIG. 2

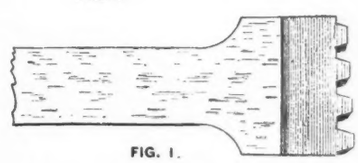

FIG. 1.

of apples, turn out only 600 to 800 cider mill press screws each, will this year make 3,500 to 4,000—four or five times as many as usual will be made. This calls for screws for the presses. These are in two or three sizes—the smallest 1¼ inch in diameter and the largest 2 inches. These sizes are of the rough iron, and the actual size of the screw is $\frac{1}{32}$ inch less, as the size of the stock is reduced by turning the bar down before cutting the thread. The common practice is to cut the threads in the lathe. They are threaded from 16 to 18 inches, with very good, smooth, even threads, three to the inch on the large ones and four to the inch on the small ones. The large ones are cut at the rate of from

forty to sixty a day of ten hours. The lathe speed varies in different shops from 14 to 24 revolutions per minute.

While being cut, the screws are supported by a firm back-rest, and the tool used for removing the stock is a chaser, set in the tool-post. The chaser has four teeth, and, as a rule cuts a full thread by running over three times. The inside thread is tapped in the "beam" and is 2½ inches long for the 1¼-inch, and 4 inches long for the 2-inch screw. The beam is of a good quality of cast iron, and is tapped by running a tapering tap through it, threaded 18 inches in length. The taps endure well. Mr. John H. Kelly, of the Mast & Co.'s Works in Springfield, O., has had experience with this work for twenty-five years, and states that he has never known one of the taps to break. They fail and become unserviceable on account of wearing out. A 2-inch seven-fluted tap is now in use which has tapped out 2,000 holes 4 inches long, and shows but slight indications of wear. It is of Sanderson steel. The taps cut at the rate of 20 revolutions per minute. Lard oil is used for cutting screws and tapping "beams."

The practice at the Superior Works, in the same city, under Mr. McChristian, is to run a sizer through the "beam" after the tap. Repairs consist of keeping the sizer to the right proportions. He has the lathes for screw cutting run 24 revolutions per minute.

The shanks of the chasers are 1½×¾ inch, which makes a very fairly stiff tool. The top end and side views of the chaser, as it appears when about half worn out, are shown in Figs. 1, 2 and 3. The figure shows the effect of grinding. Fig. 3 should show more top rake. If the top rake is allowed to vary, it becomes necessary to alter the relative position of the tool to the work to retain the form of the thread; and top rake improves the efficiency of the tool.

Mr. Kelly has devised, and uses, an efficient means for making the chasers. They are forged from 1½ inch square steel, the shank being drawn down, in preference to having the head upset from 1½×¾. There is a theory involved in this practice which will bear consideration at some other time. After being carefully annealed, the scale is roughed off and the shank trued up to ensure its correct setting in the tool-post. It is then dropped into a fixture fastened in the tool-post, shank down, and fastened with a set screw in such a position that by feeding it through under the revolving "hob," which in this case is a milling-cutter, the teeth will be cut across it at the right angle, so that they will stand properly inclined when the shank of the chaser is fastened where it is to be used in cutting with it. This milling cut also gives the front rake at the same time. As it leaves the cutter it is ready for hardening. When it dulls and has to be re-sharpened, it is ground off at the top as shown in Fig. 3, and the shape of the teeth remains unaltered until the tool is ground away too much to resist the stress of cutting. The teeth are so shaped that each cuts a chip in succession, the last tooth just cleaning out the cut of the third, thus leaving the finished thread in good condition. The screws are all tried in a "beam," which is replaced every day by one of the last which has been tapped. The very slight wear of the taps is thus closely followed and agreement ensured between the beams and screws.

Bridge screws as large as these are cut in machines with dies by once running over. As the function of the nut on bridge screws is to stay after it is once set, it is not as essential that the threads be as smooth as on screws subject to the frequent turning of the nut.

In the Warder, Bushnell & Glessner Reaper Works, a square thread is cut on a screw used on their machines, which is 16 inches long, 4 pitch, in a four-jawed opening die, at the rate of twenty an hour. Experience has shown that in order to keep the pitch right for the long distance, it is necessary to use other means to draw the carriage which holds the screw, than simply the pull of the die which is cutting. When that alone was depended upon for the lead, my impression is that 64 threads occupied the space of 63 (my information is not positive on this point), but when the carriage was moved by an independent lead screw, the pitch of the thread in the screw which was cut conformed to the master screw, and the fact that the dies cut clear and did not jam the screws, was proved by their non-elongation—they didn't stretch.

With their solid die machine, Webster & Perks cut a chair screw 1 inch diameter, 16 inches long, 4 pitch, without preliminary turning, on soft steel in the rough, 300 in a day of ten hours. They adhere to their four-cut solid die, and cut 1⅜-inch soft steel screws, 6 pitch, running 30 revolutions a minute, which is a circumferential speed equal 183¾ revolutions of a 2-inch bar, but do not think it advisable to take the risk of cutting 2 inch screws, 4 pitch, at a speed exceeding 15—perhaps 12 is better—revolutions per minute. The difference in the pitch, and especially the corresponding difference in depth of thread, makes itself very conspicuous in the amount of heat generated in the operation of removing the stock.

As a number of teeth are digging in at once in cutting screws with a long chaser, there is often occasion to observe, if there are flaws in the iron, that the long cut lifts out flakes of stock, and thus spoils the screw. Although cutting with a four-jawed die is very much like running a chaser over four times, it does not affect the integrity of the stock so. It is not apt to lift the stock out in flakes, because the compression or jam of the dies rather tends, on the contrary, to keep the stock compactly together, A chip ⅛ of of an inch deep offers much greater resistance than four chips $\frac{1}{32}$ inch deep, on the principle that union is strength, and that it is easier to bend a bundle of twigs than to bend a stick of equal cross section. The thick chip will not only not bend as easily, but it will also disturb the stock more around it.

I notice there is a great difference in the angularity of the pitch of the screws—the 2-inch screw, 3 pitch, peripheral measure, on the outside of the thread, goes some over 183¼ inch to gain an inch, while the bottom of the thread goes 15¾ inch, the angularity of the outside being 3.039° and that of the bottom 3.647°. In the case of the 1⅜-inch screws, 6 pitch, a line drawn on the outside of six threads would straighten out 25.13 inches long, and one on the bottom of the thread 22 inches, the angularity of the outside being 2.28° and that of the bottom of the thread 2.6°. The angle of the dotted lines A and B as shown in Fig. 4 may be made the base of any standard, or an angle equal to an incline of ¾ of an inch in ten inches, as A E D may be preferred, no rule is inflexible, but it is sometimes quite as well to change a rule as it is to make something by it which would have been better for its purpose, if made in some other way. Whitworths' and the United States standards agree on 4 pitch for 2½-inch screw, an incline 31.41 inches long equal to an angle of 1.82°.

It has been argued that the best way to remove the stock from a square-threaded screw is to run in a square end tool first and cut a channel to the full depth and follow with a finishing tool, trimming the sides of the thread. It is claimed that the channel gives space to accommodate the chips cut from each side by the thread tool, and gives them a chance to come out without being crowded upon each other, and that the cut will be easy in proportion as the chip is less compressed. In these days of plentiful power it don't make a picayune's difference whether the tool cuts easy or hard, so that it does its work quickly and well, and is not subject to excessive stress.

If this method had been tried and after due consideration had been deemed of practical importance, the teeth of chasers and dies as well as those of the taps, could have been easily modified to take advantage of it. The teeth in the advance could have been made narrow, increasing gradually in length, only while the finishing teeth were widened and shaped to their perfect form. It would not be difficult to accomplish this either on dies, chasers, or taps. It is of the nature of an adaptation of the principle which causes "clearing teeth" to be set at intervals in saws.

Let us consider the mode of operation in cutting with a single point, a multiple point, or chaser, and in dies. Take the inch screw cut one-eighth of an inch deep at once running over with a four-jawed die, five teeth cutting on each jaw, every tooth doing equal work. There are twenty teeth engaged, and each is cutting $\frac{1}{20}$ of ⅛ of an inch, which is $\frac{1}{160}$ inch. Now take the four-tooth chaser and run it over three times to cut the full depth thread—say that an average cut is given to each tooth, although, as a matter of course, the last tooth takes the least—we have then three cuts with four teeth cutting, which is equal to twelve teeth cutting, and each cut would be $\frac{1}{12}$ of ⅛ inch, which would be $\frac{1}{96}$ of an inch. If any one was cutting this thread with a single-pointed tool, he would hardly think of going over it more than six times, and this would require that $\frac{1}{48}$ of an inch should be taken at each cut. The first cuts might be taken with a narrow tool, as mentioned above.

In considering what method of cutting screws is the best to adopt in any instance, the economy in making, using and replacing the tools is to be taken into the account. A hundred screws could be cut quicker with a solid die than with a single point, but

could the screws be made cheaper in that way, including the making of the die, than they could be made with a single point? There are shops where this would undoubtedly be the case, but they are shops which have taken advantage of the experience they have had in the past.

Some interesting statements have been advanced in regard to the formation of the threads of screws by rolling. In the spaces between the threads the iron is compressed, moved from its position, part of it jammed up to form the thread, and part of it elongated, stretching the screw. The wood screw thus made is a common example; the threads look somewhat burry; they bear the marks indicating that they have been thrown up as burrs. It is said that excellent screws for iron work are thus made. Naturally the first idea that arises is that such screws would be weaker than cut screws—as though they were weakened by marking around them with a cold chisel. But it is claimed that they are stronger, and that tests have proved it. It is possible that they may resist a greater tensile stress, but it is tolerably certain that they are weaker to transverse shock; they break easier with a blow. It is said that bicycle spokes are thus threaded, and the bicycle repairers say that more spokes fail from stripping the threads than break, either the headed or the threaded end—they break about as often at one end as at the other. Whether it is the rolled or the cut threads that strip most, or break most, has not been made the subject of investigation.

Revolutions never go backward, but they sometimes falter. There may come a time when the elongation by rolling may save stock enough to more than pay for the operation of rolling on the threads. We have seen it stated as evidence of the good quality of screw-threading tools, that they did not elongate the stock, but the elongation is one of the advantages of rolling. If more stock can be squeezed out of the bolts than pays for rolling the threads, screws can be furnished for less than the stock would cost which would be needed if they were to be cut.

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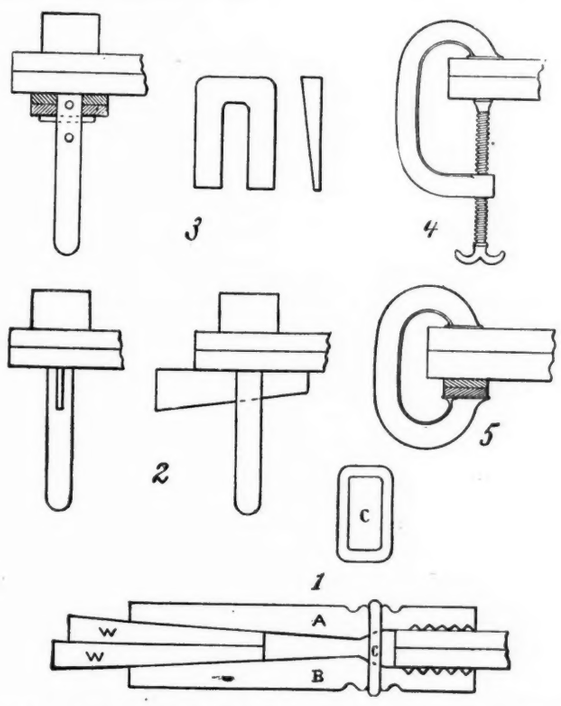
MACHINE SHOP NOTES.

CLAMPING FLANGES, ETC.

ROBERT GRIMSHAW.

It often happens that it is desirable to clamp two flanges or other pieces together temporarily, as while drilling bolt holes,



marking the position of bolt-hole centers in one piece to correspond with those in the other, etc. To do this there may be used any one of a number of devices, some of which are here shown.

The first, illustrated in Fig. 1, consists of a pair of pincer-like clamps having a movable fulcrum, by which the leverage may be altered. There are two jaws, A and B, exactly alike, and each having rounded notches in which there may engage a link of rectangular outline and round cross-section, C. The jaws are corrugated or toothed, so as to prevent slipping; and the handles are pressed apart (which causes the jaws also to be pressed together)

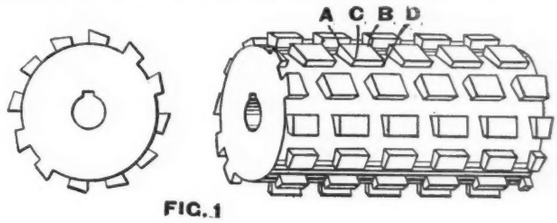


FIG. 1

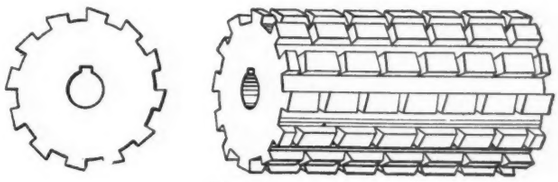


FIG. 2

by a pair of wooden wedges, *w*, *w*. For these, a screw may be substituted. These will clamp flanges that have no holes at all in them, and do not take up much room crosswise.

Where the bolt-holes are already in the flanges, the slight device shown in Fig. 2 will answer admirably—consisting of a bolt with a large head and slotted stem, through which there is thrust a thin wide cotter C. This may be used with or without washers, according to the thickness of the flanges.

Fig. 3 shows a modification of this. Instead of there being a slot through the shank of the bolt, there is only a series of round holes through any desired one of which there might be thrust a round pin; and wedges driven between this pin to the lower flange will tighten up the whole.

Fig. 4 shows the ordinary screw clamp which may be used with or without plugs between it and the flanges; and Fig. 5 is the same thing used without any screw, wooden wedges taking the place of the latter.

SPIRAL FLUTES IN MILLING CUTTERS.

Very often when a milling cutter fails to come up to the expectations of the man who made or designed it, the stock is complained of as being soft or unequal, when it is only the form of teeth (for they may be called so) or the number and disposition of flutes, which causes the trouble.

In the Newton Machine Works, after making many experiments on cylindrical cutters for slabbing, one was found which at first gave great promise of long hard work. It was made with flutes parallel with the axis, and then each flute was cut up by spiral channels so that the entire tool presented a number of lozenge-shaped teeth arranged about its circumference in parallel spirals; the teeth being probably three-eighths inch lengthwise of the cutter (along line A B) and the spiral channels one-fourth inch wide; while the parallel flutes were about one-fourth inch wide and one-half inch between centers. Each tooth was of course "backed off" along one edge as on line C D. It would be supposed that such a cutter would mill right along smoothly without hitch or mark; but as a matter of fact it left very perceptible ridges. This was doubtless because the spacing was too regular. Another form was tried (like the former), of case-hardened crucible machine-steel, with parallel flutes as before, but instead of the teeth being divided by regular spiral channels, they were somewhat irregularly divided by cuts which formed nowhere a complete nor a regular spiral. The result was very rapid cutting without being marred by lines as before.

This is probably somewhat on the same principle that hand-cut files are considered (without usually assigning any reason) to do better work than machine cut; because the latter as usually made (in fact as made by all manufacturers except the Nicholson Co.) are too regularly spaced; and the matter also calls to mind the fact that taps with an even number of flutes, regularly spaced, do not do so good work as those with an odd number, spaced a very little out of symmetry.

THE INERTIA GOVERNOR.—3.

J. BEGTRUP.

All oscillating bodies have a natural period of oscillation, as when a pendulum oscillates freely under the action of gravity; if there are other forces acting regularly, alternating in opposite directions, they will generally produce a certain periodicity in the oscillation, and there may appear a greatly magnified oscillation if the period of the disturbing force is nearly equal to the period of the free oscillation, otherwise it will have but little influence. As an example, consider a swing which, after being set in motion, will continue to move to and fro, and suppose two persons

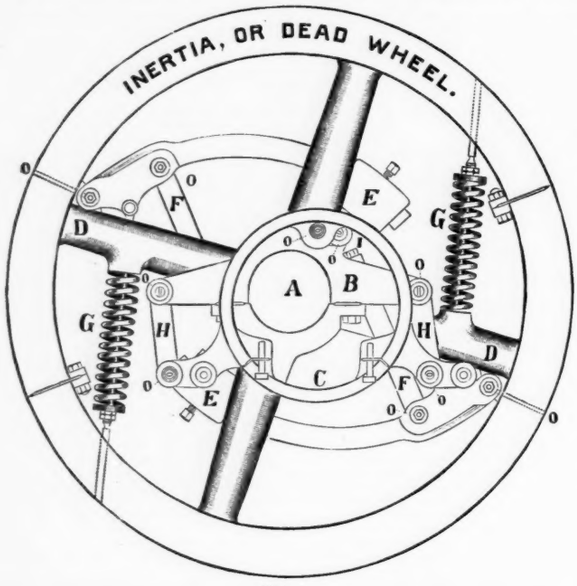


FIG. 4.

pushing lightly in each direction in perfect harmony with the motion of the swing, this will greatly increase the swinging even by very slight efforts, for in this case the period of the disturbing force coincides with the period of the free oscillation; but if the pushing be done regularly at shorter intervals not coinciding with the periods of the swing, the effect will be far less and the motion will be periodically varying in extent. Now a belt connecting the driving pulley on the engine shaft with the dynamo is free to oscillate up and down, and if the period of free oscillation nearly corresponds to the stroke of the engine, the small fluctuation in speed of the driving pulley may produce a magnified oscillation of the belt, and in such cases a light fly-wheel *may* be the indirect cause of irregular driving. But if the belts are long, not properly made or too stiff, and not tight enough, they will flap and surge without regard to size or weight of fly-wheel, and the motion is generally much too slow to correspond with the stroke of a high speed engine. Some claim that it is caused by air getting between the pulley and belt.

Irregular driving may also be caused by faulty valve-setting or by a lack of stability in the governor. If it was caused directly by a too light fly-wheel, it should certainly be expected that a dynamo directly connected to an engine, having exceptionally light fly-wheel in proportion to its power, would reveal the effect of the periodic fluctuation in speed if such was of any consequence. There can be no doubt as to the existence of such fluctuation; neither can there be any doubt as to the correctness of the calculation by which the amount of fluctuation is ascertained, and the only explanation I can give for the trifling effect on the voltmeter and tachometer is that the great frequency of the fluctuation does not permit it to effect the current or to be recorded by these very sensitive instruments. Still more delicate instruments could probably be made to indicate the fluctuation correctly, but the experiments with a first-class commercial tachometer are more interesting from a practical standpoint, for if such instruments do not show any fluctuation, we may safely assume that it will under no circumstances be of any *practical* consequence.

The action of the belt which drives the tachometer is very instructive. In nine out of ten cases I have found that when the tachometer showed a continuous fluctuation in rotative speed, it was due to the belt or the driving pulley. That the instrument is sensitive can be shown by touching the belt, which immediately shows on the dial, and if there is any lumpy lacing it will certainly show. I have often noticed that after a new tape was put on, the hand would stand perfectly still, also that when the tape touched the side flange on the small tachometer pulley it would always show some fluctuation in speed. Such fluctuation is, of course, reproduced on a larger scale when anything is the matter with the belt which drives a dynamo. Flapping of the belt has the effect of shortening or lengthening the driving side which will cause minute variation in the speed of the driven pulley. I have seen the tachometer belt run direct from an engine shaft which had a key-way cut in it; this caused a considerable variation in the speed of the tachometer, but when I put my hand on the belt so as to stop its undulatory motion, the speed of the tachometer would be practically uniform. The direct effect of the key-way was exceedingly small, but the indirect effect from the flapping of the belt was much greater. I have also occasionally noticed that irregular driving is caused by slipping of the belt, but I do not know of a single case where it is caused directly by a too small fly-wheel. In every case which has come under my observation it was caused by the condition of the driving belt or by the action of the governor. There are, however, special reasons why fly-wheels should not be too light, but they cannot be discussed here.

Since the above was written, the 300 HP. tandem compound engine and dynamo which was mentioned in my last article, has been installed, and there was not the slightest flickering of the lights; and I can therefore make the positive, unrefutable assertion that a fluctuation in speed of 3 per cent. with a frequency of 6 per second has no perceptible effect on incandescent lights.

The momentary variation of speed when part of the load is suddenly thrown on or off is not correctly shown by the tachometer, and it can not even be approximately estimated from the voltmeter on account of compounding of the armature which varies the electromotive force, but it is exceedingly small with a properly constructed inertia governor; say from one to two per cent. from mean speed when half the load is suddenly thrown on or off. But when this is done by the prony brake it is often impossible to detect any variation. When the motion of the governor weight is extremely quick, as indicated by the spiral in Fig. 2, the momentary fluctuation in speed will, of course, be very slight, and it is hard to conceive of any better governing. Some oscillating of the

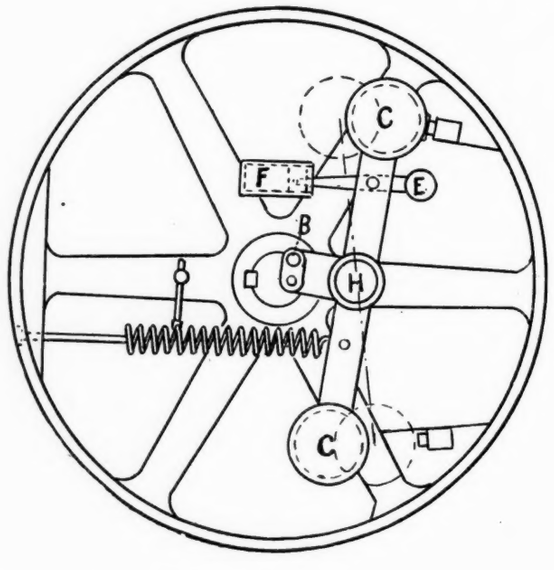


FIG. 5.

weight would be necessary for close regulation, for after the speed has been retarded or accelerated, it would be necessary for the governor weight to take a momentary position on both sides of its final position of equilibrium in order to obtain a quick restoration of the proper speed.

I have not the least doubt that it has often been found that a large and heavy fly-wheel improves the regulation, and that a closer approximation to isochronism may be obtained with a heavy wheel, for it can be shown by mathematical analysis that the stability of a centrifugal governor is greatly increased by increasing the moment of inertia of fly-wheel; and some governors need heavier fly-wheels than others. But we have had no such experi-

ence, nor has it ever been expected, for it can be shown analytically that the inertia governor should be equally effective with light and heavy wheels, and the test referred to in my last article and many other similar tests seem to indicate a perfect harmony between theory and practice in this case, which, of course, is another way of saying that my theory seems to be correct and complete.

This is my last point of consequence in favor of the inertia governor, but I could mention others of less consequence but very interesting, as when starting up our engines with full steam I have often noticed that the hand of the tachometer would walk right up to the mark and stop there. Is this possible with the centrifugal governor? I think not, it will always over run more or less when starting up. I have also noticed that our governors can be greatly out of gravity-balance without detriment to the regulation; also that the speed may *increase* nearly 20 per cent. under full load without destroying the action of the governor.

Since the advent of high speed engines and shaft governors the regulation has improved greatly, but the speed of the Corliss engine is still in many cases controlled by the old style Watt's governor, which probably is as good as any gravity-governor and will do tolerably well with enormous fly-wheels. But why not use inertia governors and get a regulation as close as can be obtained with a shaft governor, besides an occasional saving of many thousand pounds of fly-wheel? If any one should ask me: "Have you not found anything to say against the inertia governor?" my answer would be, honestly and truly, that I can't find anything unless it be this: that it will not anticipate a reduction or increase of the load on the engine and adjust itself to meet such changed condition and thereby entirely avoid any momentary fluctuation in speed. Of course, objectionable features may be found in inertia governors, but they can be corrected, and in no case is the underlying principle to blame. I certainly think it will eventually come to the front if "survival of the fittest" be anything but an empty phrase.

Fig. 4 represents an inertia governor invented by Matthew R. Moore and built by Atlas Engine Works, Indianapolis, Ind. It is a shaft governor for a single valve engine. D is the inertia mass, being formed as a wheel loosely fitted on the hub of the tripod B, which is keyed to the shaft. The centrifugal weights E E are pivoted to the inertia wheel and connected to the short arm of the tripod by links F F. C is the eccentric pivioted to the tripod and connected with the inertia wheel by link H. Suppose this governor to be turning in the direction of the hand of a watch and let there be a sudden increase of the load on the engine, followed by a momentary retardation of speed, then the inertia wheel will move ahead of the tripod and weights E will be drawn in toward the shaft, the throw of the eccentric will be increased and more steam will be admitted, corresponding to the greater load. At the same time there will be a momentary diminution of centrifugal force and, therefore, a perfect co-operation of the centrifugal weights and the inertia wheel.

A similar governor with inertia wheel was built by the Atlas Engine Works as early as 1883, and one of these governors was applied to a slide valve engine for a flouring mill belonging to D. W. Marmon, at Richmond, Ind. A great number of these are now in operation in different parts of the country.

The inertia principle is very plainly set forth in Mr. Moore's patent of May 26, 1885.

An interesting inertia governor was patented by Bancroft and Lewis in December, 1886. I think the inertia wheel was put on a Buckeye governor in the shops of Wm. Sellers & Co., of Philadelphia, in the winter of 1885. The distinctive feature of this invention is elastic connections, as helical springs, between the inertia wheel and the centrifugal weights, which gives a degree of independent motion to these parts. It is assumed by the inventors that the motion of the inertia wheel on its bearing is slower than the corresponding motion of the centrifugal weights, and on any change of speed of the engine these weights move first, compressing or extending the elastic connections until equilibrium is restored, when they are left in their natural unstrained condition. The dynamic condition after a change of load will therefore be similar to that of an ordinary centrifugal governor having the initial tension of the springs greatly reduced. But the prejudicial effect of such adjustment in an ordinary centrifugal governor is here entirely obviated by the motion of the inertia wheel on its journal, for it will, in a short time, accommodate itself to the new position of the centrifugal weights, leaving the elastic connections in their natural passive condition. The inertia wheel simply forms a *movable* abutment for the elastic connections and gives great stability to the governor system

It is interesting to note the similarity of this invention to the combination invented by Mr. Frank H. Ball, and which consists of a spring connecting the centrifugal weight with the piston in an oil dash-pot. The resistance of the oil in the dash-pot has an effect somewhat similar to the resistance of the inertia wheel in Bancroft & Lewis' governor, that is, it forms a sort of movable abutment for the connecting spring. It is, of course, to be understood that these governors have also centripetal acting springs which oppose the centrifugal force of the weights in the usual manner and regulate the speed of the governor precisely as in ordinary centrifugal governors; but on account of the greater dynamic stability obtained by the elastic connections, the centripetal springs may have full theoretic tension, or nearly so.

Fig. 5 shows the inertia governor used on the McEwen engine. It is of later date, and is remarkable for its extreme simplicity. C is the double-armed inertia weight pivoted on the outside of the governor wheel. The eccentric is a stud attached to the inertia weight at B, and the centrifugal weight is bolted to one end of the inertia weight, which is cast hollow to receive it, and there is only one helical spring on the governor. The bearing on the pivot H is a roller bearing of tempered steel, which requires no oiling and offers very little friction, and the necessary friction is supplied by an air dash-pot F; this is a smooth open cylinder with a loose-fitting piston, which is balanced by a counterweight so as to avoid friction under centrifugal action; the result is a governor which requires no lubrication. The principle or theory which led to the design of this governor is briefly this: The action of direct inertia is very desirable, but some friction is necessary for stability; sliding friction is not desirable, because it is impossible to avoid friction of rest and it necessitates lubrication. Air confined in a small cylinder will supply sufficient resistance for an inertia governor and is not objectionable; hence the best result is obtained by the combination of an inertia weight, frictionless bearings and an air dash pot. Hundreds of these governors are now in use and give entire satisfaction. The construction is covered by several patents.

* * *

AN INTERESTING LAWSUIT.

During the winter of 1890 and 1891 the mechanical papers were much interested in the trouble which was being experienced by the Edison Electric Light Company, of Philadelphia, with the Abendroth & Root boilers, which they had in their station, and opinions pro and con were expressed to the cause or causes which produced the lamentable accidents which were occurring there. A trial in the United States Court, in Brooklyn, has just been completed between the Edison Electric Light Company, of Philadelphia, plaintiff, against Abendroth & Root Mfg. Company, of Brooklyn, defendant, for the recovery of $35,000 spent by the Edison Company in putting the Root boilers in proper running condition. The case has occupied fifteen days in trial and testimony covering the causes and results has been most complete. To those who are not familiar with what was happening at the Edison Station in 1890 and 1891 we will briefly state the circumstances:

No. 1 battery of three boilers of 300 HP. each was installed in the fall of 1889, and an order for a No. 2 battery was placed with Abendroth & Root immediately on completion of No. 1. As soon as No. 2 battery was fired, trouble began to be experienced in the breaking of bolts holding the bends and headers together. The breakage of these bolts was almost continuous; often it would be discovered before a serious accident would occur, but very frequently a bend would be blown completely off, filling the boiler-room with scalding water, burning the men in charge of the boilers, and flooding the engine-room and dynamo room which were on the floors below. As the boilers of No. 2 battery were not yet accepted by the Edison people, the manufacturers were doing everything in their power to stop the accidents, but with little success. No. 1 battery was seemingly working all right. Very little trouble was experienced with it and it consequently was doing nearly all the work of the station. The water which was being used at the Edison station was water taken from a well and had about 34 grains per gallon of solid matter, mostly salt, held in suspension. This caused No. 1 battery to scale quite badly, but no serious results followed. As the boiler people were confident of their ability to stop the accidents, the batteries Nos. 3 and 4 of

900 HP. each were ordered and immediately upon their installation the same trouble began which was occurred No. 2 battery. These accidents became so frequent that a heavy flooring was placed across between the fronts of the boilers separating the firing space from the upper part of the boiler, and huge movable bulwarks were placed in front of the doors of the boilers in operation so that men cleaning the boilers on the opposite side would be protected in case of accident. Prof. William D. Marks, who was the general manager of the company, was aiding the boiler people in every way to get at the true cause of these breakages. In addition to the breakage of bolts, the tubes in the lower doors of the boilers were burning out and bursting continuously. As many as ninety new tubes were put in these three batteries in a month. No one who was not on the ground could imagine the terrible trouble and anxiety experienced by the Edison people during the latter part of 1890 and the spring of 1891. The engineer in charge was made ill by nervous prostration. Prof. Marks, whose duties should have kept him elsewhere, was almost constantly in the boiler-room, often in clouds of steam, working day and night. He even gave up his room at the Continental Hotel and took one immediately back of the station, so that he could be called upon at any instant during the night, and for months he scarcely slept a single night without being called up on account of some of these accidents. At first the trouble was ascribed to bad bolts, and most exhaustive experiments were tried with them. Steel was substituted for iron in their construction and afterwards rivet iron, but all to no purpose.

In the fall of 1890 Mr. Abendroth sent to Philadelphia the chief engineer of his company, Mr. Huggentoebler, a man of great experience and good judgment, to investigate and decide on the cause of the accidents, and what should be done to remedy them. Mr. Huggentobler, after an exhaustive investigation, made a report to his company in which he said that the requirements of the station were such that heavy firing of the boilers was necessary, and the water that they used was extremely bad. He also reported that the real cause of the accidents was rigidity between the headers and bends, causing the bolts to bind in the slots of the lugs in both headers and bands, and that excessive expansion and contraction of the tubes caused them to break by flexure, and recommended that the patterns be changed so that the bends would have more chance to move by expansion without binding the bolts. This latter part of his report was suppressed by his company, and only that part of it referring to the heavy firing and bad water was sent to the Edison Company. Prof. Marks, on his own account, had come to the decision that the binding of the bolts was what was causing the accidents; he, however, wished the opinion of other experts, and called in Mr. W. D. Ruggles, the Superintendent of the Pennsylvania Boiler Insurance Company, at Philadelphia. Mr. Ruggles reported, as had Mr. Huggentoebler, that the cause of the accidents was the excessive rigidity of the parts causing the bolts to break by a flexure, and recommended a ball and socket joint between the head of bolt and lug of header. This report was sent to the Abendroth and Root people and was answered by their Mr. Merrill, who was their Philadelphia sales agent, and not an engineer, denying that the causes of the trouble were as stated, laying all the cause to excessive firing. Soon after this an accident occurred in which a man was killed, and the coroner's jury censured the Edison people for the accident. Prof. Marks then took the matter in his own hands and made the changes as recommended. About this time the certificates from the chief boiler inspector of Philadelphia had expired and new certificates were asked for. Mr. Overn, the chief, refused to sign such certificates, and the station was in danger of being closed down thereby. Prof. Marks thereupon called upon Mayor Stuart of that city to appoint a commission to examine and report on the causes of the accidents and what might be done to prevent them. This commission was composed of three expert mechanical engineers of the city, and the result of their examination and report is a curiosity in its way. They refused to accept the suggestions which had been offered as to the rigidity of parts, went to the office of the Edison Company, examined the log-book and discovered that the gauge pressure measuring the blast was marked on the log-book as varying from 1½ to 2½ inches of water. They did not examine the fans, the manner of connecting the blast with the boilers or where the gauge was placed, but sent to the Mayor a voluminous report claiming that the blast pressure was too much and should be reduced to $\frac{3}{10}$ of one inch under the grates. As it happened, the gauge for measuring this blast pressure was placed in the blast boxes near the fan, and the readings for the log-book were taken from it every fifteen minutes. This blast pressure did not show the blast under the grates, but on the contrary its highest readings were when all the gates to the boilers were closed and no blast at all was being used. Prof. Marks had small gauges placed connecting with the ash-pit of each boiler, and found that without reducing the revolutions of the parts or the amount of blast in any particular he could get but $\frac{3}{16}$ of an inch under the grates. He therefore took down the gauge in the blast-box, had the commission examine again and his certificates were allowed; that is, all the changes he made were to change the positions of the gauge and in no way decrease the blast which he was using, but the experts were entirely satisfied and he was allowed to run his boilers. The changes of headers and bolts went on, and after a boiler had been gone over and all the changes made, giving proper elasticity and flexibility, no accident has ever since happened to that boiler. All the boilers were taken off in turn, and since the completion of the work not a bolt has been broken nor a head blown off.

On the trial which has just been in progress, the defense has been throughout that overfiring of the boilers caused all the trouble by producing a water-hammer at the bends, a theory expressed by Mr. Overn at the coroner's inquest above referred to. Prof. Carpenter, of Cornell University, and Mr. Chas. E. Emery, of New York, the experts for the defense, handled this theory very gingerly, merely saying that it might have occurred; but from figures which they made on the log-book they decided that the batteries were pushed beyond their rated capacity, their opinions being all taken from the amount of coal consumed and distributed throughout a period according to the amount of electrical energy produced at any given time. The experts for the prosecution, who were Prof. Marks, Prof. Spanger, of the University of Pennsylvania, Mr. Codman, of the Philadelphia Water Works, and Mr. Ruggles, of New York, all held to the opinion that bad workmanship was the cause of the accidents, and that the boilers had not been pushed beyond their rated capacity of 300 HP. each. They figured the power in each case from the amperage which was taken every quarter hour from the log-book, and found but seven cases where the total power exceeded the guaranteed power, and these for only a few minutes at a time. Prof. Emery, on rebuttal, admitted that if the quality of coal was such as testified to by the prosecution, then a certain percentage of reduction should be made from the power estimated by him; taking this percentage and figuring from it, the result was almost identical with that given by the experts for the prosecution, who had figured back from the electrical load.

One of the most important changes made by Prof. Marks was the change in the method of circulation. The batteries which were put in his station were the first ever made with tubes 18 feet long and eleven tubes high. The result of this was to add a great deal of heating surface without any increase of disengaging surface. The water coming down from the drums at the rear went into the top headers and thence had to find its way through the tortuous passage to the bottom tubes. Before getting to the bottom it had to pass the mouths of eleven tubes all thirsty for water, the result being that most of it passed through the upper tubes and very little water reached the lower tubes, causing them to burn out as well as to expand excessively. He cut off the circulating tubes then entering the top headers at the rear and brought the circulating water down to the mud-drum at the bottom, so that the bottom row of tubes should be furnished with water first. Since the introduction of these circulating pipes, the burning out of tubes has entirely ceased.

Of course it is impossible in such a brief article to give all the points that were brought out on the trial by both sides. The summing up of attorneys on either side, Benedict & Benedict for the defense, and Mr. Boardman, of Tracy, Boardman & Platt, for the prosecution, was most excellent. Mr. Boardman's address in particular was a most masterly effort, and showed that he had thoroughly grasped all the mechanical details of a very intricate case. The judge's charge was very fair, the most material point being that it did not matter whether the Edison people used their boilers beyond what they should have done or not, if they did not force them beyond the capacity guaranteed in the contract. To the surprise of all disinterested persons who listened to the evidence on both sides, and the charge of Judge Wheeler, the jury brought in a verdict for the defense. A notice of appeal was made, returnable on January 15th, 1896.

THE HENRY R. WORTHINGTON CO.'S SHOPS.

It would be difficult in a short article to give an adequate description of the machine shops in the works of the Henry R. Worthington Co., situated at South Brooklyn, N. Y. They occupy two city blocks, and like all other shops of slow growth have had many additions and changes made in the last forty years.

In Fig. 1 is shown a powerful drilling machine, with two 4-inch spindles capable of doing very rapid and accurate work. This machine is fitted with a truck, in the center of which is a turn-table, making every part of a large casting very accessible to the machinist.

The car is moved by a rack and pinion through the bevel and spur gearing shown, which is operated by the handle at the left, and it can be locked solidly in any desired position when necessary.

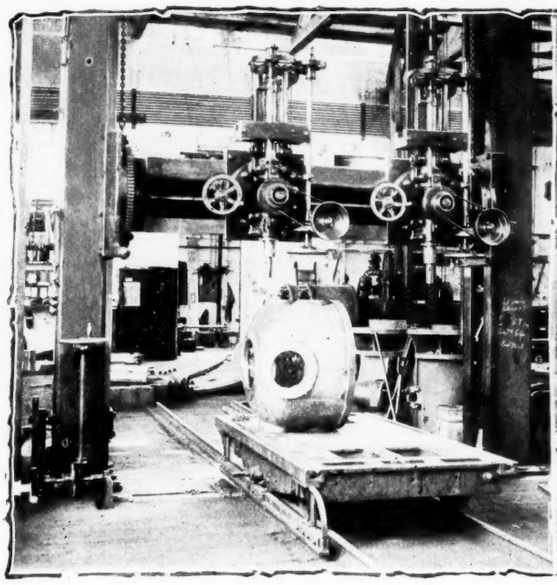


FIG. 1.—DOUBLE SPINDLE DRILL.

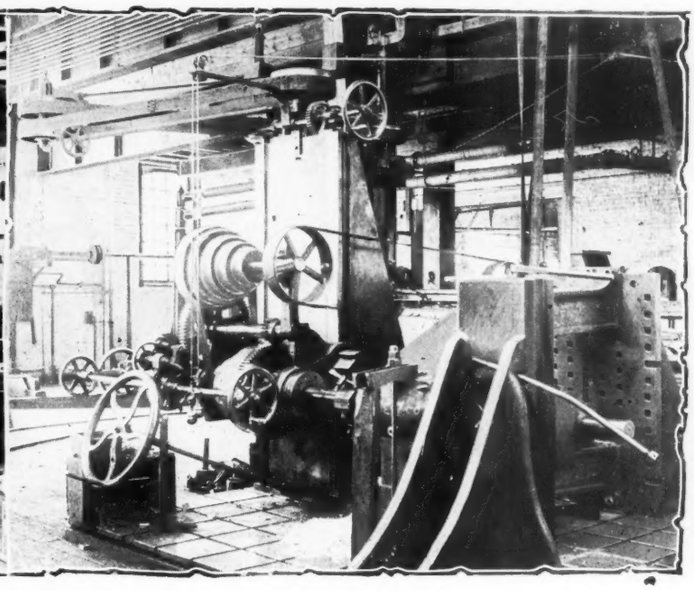


FIG. 2.—UNIVERSAL BORING MILL.

The castings are placed on narrow-gauge railroad cars by a steam derrick on board the company's steamer "Daniel Wheeler," drawn by horses a distance of two city blocks to the works and distributed to the various shops, the smaller castings being distributed in boxes holding about four tons each, thus saving a large amount of handling.

For the heavy work they use tools built by Bement, Miles & Co., William Sellers & Co., Brown & Sharpe Co., and a few other well recognized builders of fine tools. We illustrate a few of the more uncommon ones, although they cannot be called special tools.

There are many heavy tools in this shop, among them being a 16-foot and a 10-foot boring mill, 120-inch, 100-inch, and 84-inch lathes; 100-inch, 84-inch and 72-inch planers enough to keep a 25-ton electric traveling crane busy ten to fifteen hours per day. There are quite a number of other tools of such sizes that smaller cranes are used for handling the work, and a still greater number that can be served by hand.

In Fig. 2 is shown a universal boring machine, which was made by Wm. Sellers & Co. It bores at any angle, as can be seen from the arrangement of belting and gearing. This enables the work to be placed in the most convenient position and the tool adjusted to it, which is often easier than setting the work in an exact position, especially as the pieces sometimes weigh 25 tons.

A large rotary planer (which is simply a type of the milling machine) is shown in Fig. 3, being used to surface work of large dimensions. The table is of heavy construction, as befits a machine of this size. The cutter or milling disc is five feet in diameter and carries 62 cutters, which are given a lead of about 15 degrees in the setting. They are held by set screws and are ground and set by a gauge devised by Mr. Flinn, the superintendent, so the entire set can be ground (on both ends) and set, in about an hour. It will be noticed that one of the cutters to the left of the top has an inward projection, which acts as a smooth-

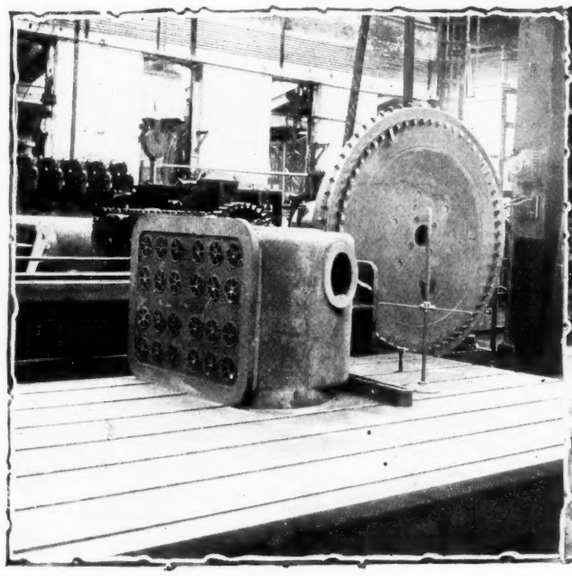


FIG. 3.—ROTARY PLANER.

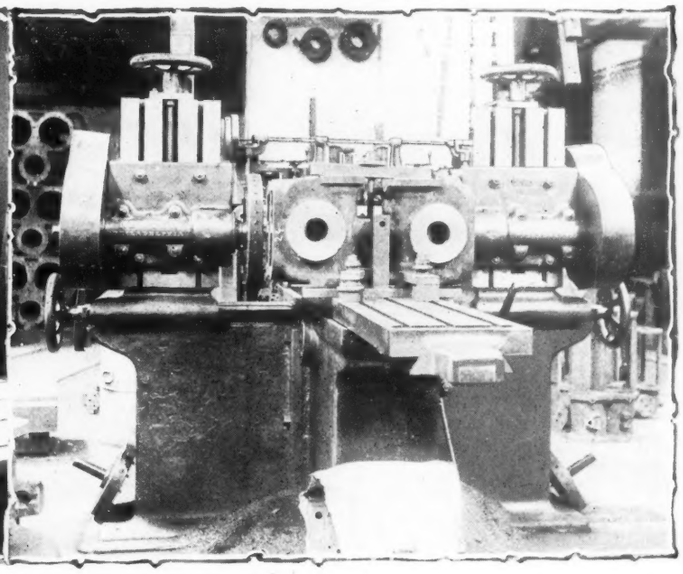


FIG. 4.—DOUBLE-HEAD MILLING MACHINE.

ing tool. The feed in ordinary work is about an inch per revolution of the disc, or $\frac{1}{62}$ (.0161) of an inch per tooth, and this

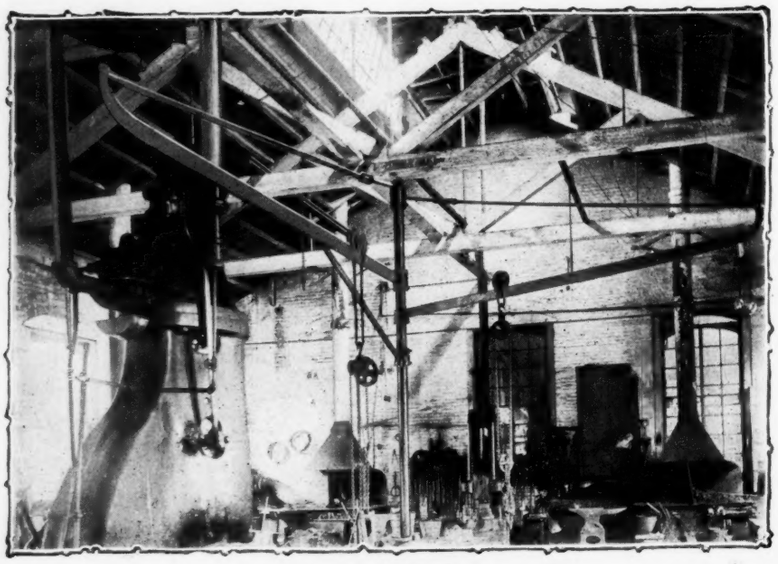


FIG. 5.—BLACKSMITH SHOP.

leaves a good surface on the work. This is electrically driven, as are several of the large tools in the shop, the starting rheostat being shown in the picture.

Another milling machine, by the Newton Machine Tool Co., of Philadelphia, is shown in Fig. 4. It is a double-headed machine, with large mills having inserted teeth, as shown. This machine stands in the breach between the milling machine and rotary planer, it being rather hard to draw the line in this case. This can probably be solved best by classing all surfacing work done with rotary cutters as milling, leaving the machine which cuts with a reciprocating motion in the planer class. This machine leaves the surfaces of the pump cylinders shown in good condition, and the work is done quite rapidly and is also well done. The blacksmith shop is not very extensive, as there is little forged work on the pump of to-day; the view was taken to show the two jib cranes on the one post; these serve the entire shop. The artist, in retouching the dark shadow in the upper left-hand corner, has shown the crane on this side of the steam hammer, when in reality it is the other side, and only comes to the hammer, thus serving the left half of the shop while the smaller one takes care of the right. The group on page 137 shows some of the products of the works, Fig, 6 being an electrically driven pump of substantial design. In Fig. 7 is shown the pum end of a pump for high pressure service, designed for a pressure of 1,000 pounds per square inch. It is being erected under the heavy swinging crane shown, which makes erection not only easy, but economical. Two other cranes of this type are seen at the left, and the shop is especially well equipped in this respect, many of the lathes having an independent crane with a chain hoist. This is a feature which can be installed at small expense, and will pay for itself many times over in almost any shop. The lower figure of the group is a triple expansion pump, which is designed for pumping gas in a Western plant, and is quite an extensive piece of work. The arc lamp at the left shows the system of lighting the works.

The testing room is fitted up in a very substantial and economical manner, and has accommodations for testing about fifty pumps at once; the room is all cement floored and has a sunken track down the center, on which the cars of their "inter-shop" railway are run with the pump to be tested. The top of the car is level with the testing floor, and the pump, which is mounted on the small trucks shown in Fig. 9, is run off the car on the testing track and moved into position for testing. The ball joints and flexible piping shown make tight connections possible regardless of the exact position of the pump, and the tests are thoroughly yet rapidly made. The pump shown is one of the well-known Worthington independent condenser type. These testing tracks run both ways from the sunken track, and pumps of almost all sizes can be seen being tested at one time. Some of the smaller ones for feeding the boilers of small yachts are almost small enough for a paper-weight, making the large ones seem larger by the comparison.

In Fig. 10 is shown a vertical miller at work on packing rings, and though the spindle seems to be supported by the invisible ether, it is in reality very materially connected to the frame of the machine. The rings are clamped in the right position on the turn-table and faced on both top and side at one cut. This is done in preference to turning in a lathe in the usual manner. There are many other tools of interest, but no more can be shown at this writing.

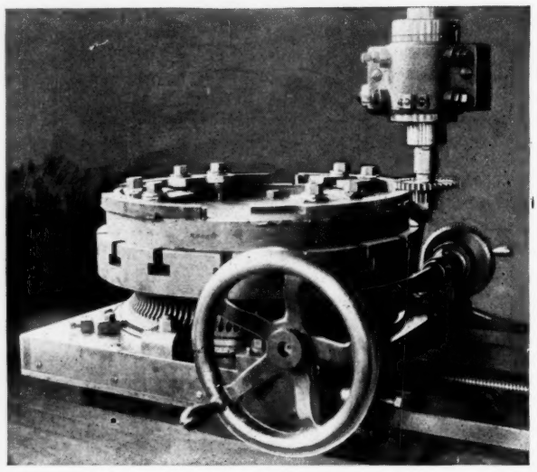


FIG. 10.—MILLING PACKING RINGS.

* * *

THE STEAM ENGINE.—1.

HEAT, STEAM AND CYLINDER CONDENSATION.—COMPOUND ENGINES.

F. F. HEMENWAY.

In the early days of steam engineering, after the crank had been applied, but little attention was given to the question of economy of operation. It could be told if one engine used twice the quantity of coal that another one did, and that seemed to answer the purposes of the day.

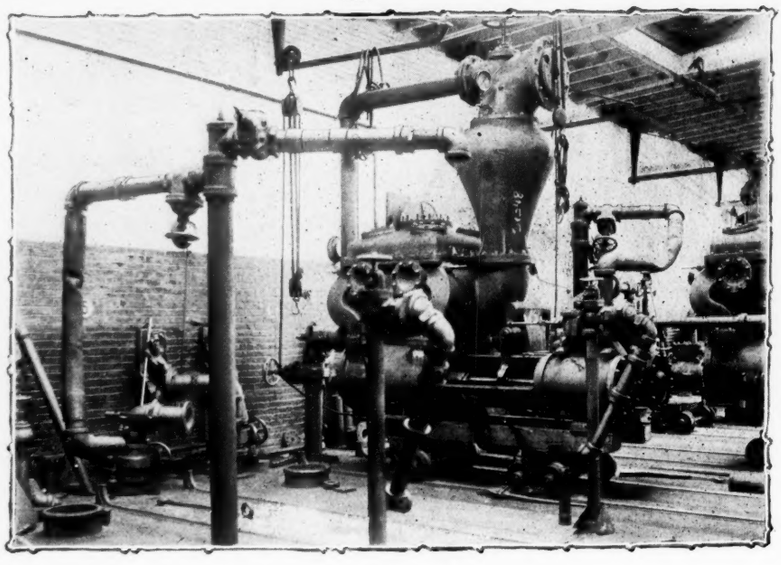


FIG. 9.—TESTING ROOM.

The reason for this was, no doubt, owing to a lack of instruments of precision, and a lack of skill to use them. Had the skill been at hand the instruments would have been forthcoming. For lack of the use of such instruments we are left very much in the dark as to the actual performance of the early steam engine. It is rather apt to strike the student of steam engineering that all manufacturers, particularly of steam engines, were especially and mainly interested in not letting others know what they were doing, and incidentally in what advances they were making themselves. There was, as far as we can see, a sharp competition in keeping things from others, and sometimes, then as well as now, in stealing other's ideas.

This cannot be said to be the case to-day, not in this country at least, except perhaps, as to stealing of ideas. That seems to go right on as a survival of the fittest. According to observation, hiding a secret which is no secret, is of no advantage. There cannot long be much that is secret about a steam engine that is being placed broadcast.

It has been intimated that our grandfathers had no instruments of perfection in the sense in which we have such instruments to-day, and probably did not want them. They measured the coal used by the bushel, and guessed pretty much at the work that was being done. They had a convenient, if not an exact way. If one has instruments of precision he is likely to use them with a care of details.

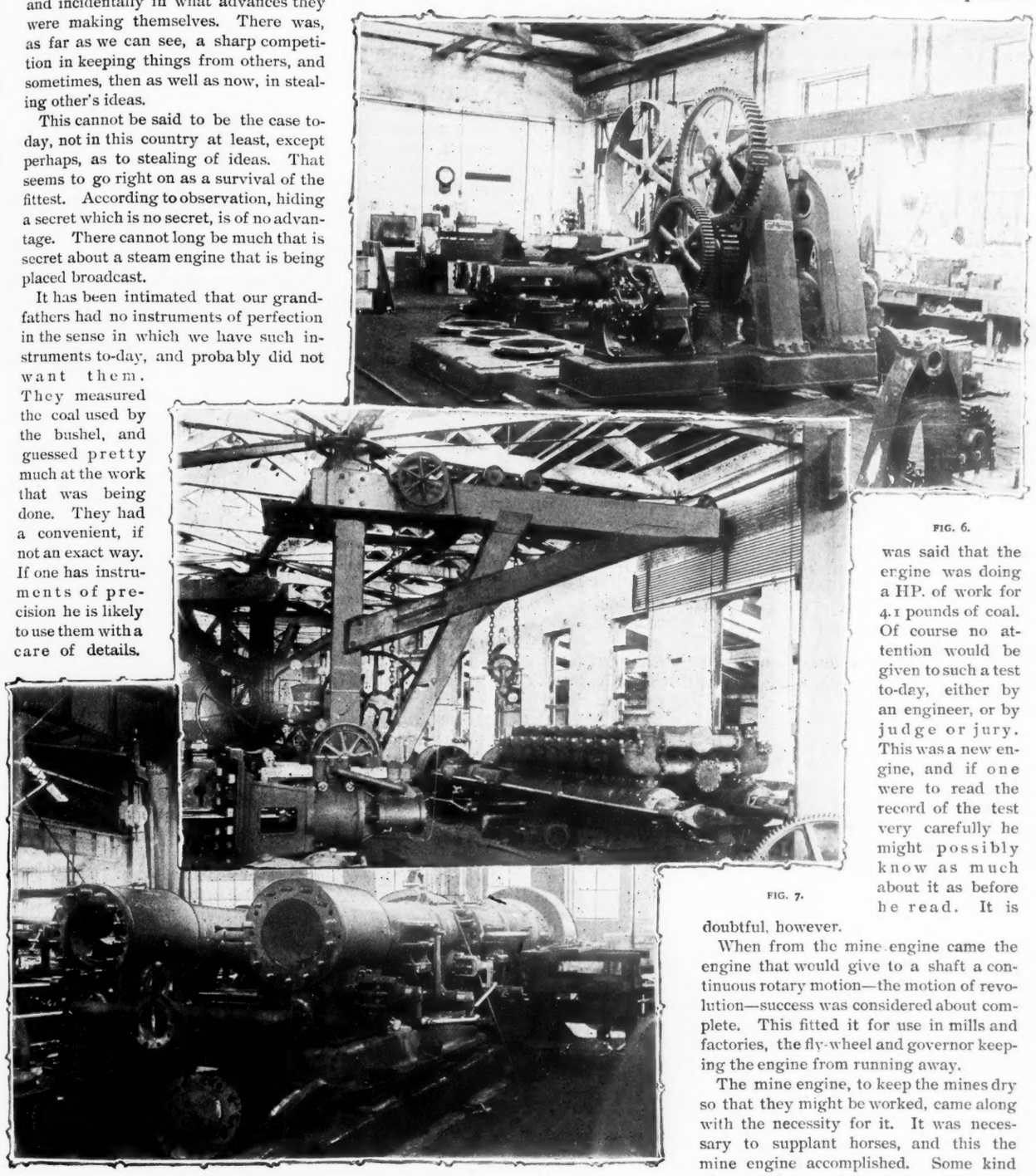


FIG. 8.—THE HENRY R. WORTHINGTON CO.'S SHOPS.

If he has no instruments for determining performance he gets careless, and does not make the observations he could make with any degree of precision, and this is why we know so little of steam engine performance—no more than a few years ago—which is much to be regretted. In such records as we have, results are very commonly compared with some kind of work done by horses elsewhere, and there are many other things that put us quite in the dark. There was a good deal of guessing all the way around.

I have read the test of a steam engine when engines were first put into cotton and woolen mills. The engine was rated at 30 HP., but it was concluded from the number of horses employed to do work elsewhere, driving a different quantity of machinery, differently located, that the engine must be doing 34 HP. of work. Then it was *assumed* that the turf burned was only, pound for pound, equal to one-third its weight of Newcastle coal, which was taken as the standard. After all these assumptions it was said that the engine was doing a HP. of work for 4.1 pounds of coal. Of course no attention would be given to such a test to-day, either by an engineer, or by judge or jury. This was a new engine, and if one were to read the record of the test very carefully he might possibly know as much about it as before he read. It is doubtful, however.

FIG. 6.

FIG. 7.

When from the mine engine came the engine that would give to a shaft a continuous rotary motion—the motion of revolution—success was considered about complete. This fitted it for use in mills and factories, the fly-wheel and governor keeping the engine from running away.

The mine engine, to keep the mines dry so that they might be worked, came along with the necessity for it. It was necessary to supplant horses, and this the mine engine accomplished. Some kind of an engine must be had, and it was forthcoming. And for similar reasons the mill and factory engine was evolved. This engine seemed to fill the needs of the day, without too much trouble about cost of operation—hunting up horses doing similar work, and the like.

At the present day it is the last ounce of coal that is looked after, and the means of determining fuel and water consumption, and power used, are so convenient to use that it is scarcely a wonder there is much competition in this respect. Perhaps it would be better to say the means of comparison instead of determing, as errors will slip in.

It may be said that it seems more than probable that the present practice, especially in this country, of looking for the last ounce of coal is not always quite right. It may cost a good deal more than it ought to. While it is desirable that a steam engine shall require but little fuel, by comparison, there are other important things to be considered. It is sometimes the case that it is far more desirable that an engine shall run every day, twenty-four hours if necessary, with little reason to look for derangement, than that the coal burned in a given time shall have weighed less by a pound. This is almost always the case, though it is not given much attention by either builder or purchaser. There is danger that too much scheming to save ten cents worth of coal will cost a good deal more than it comes to. It is good engineering to look sharply after the last pound of coal, but when jim-cracks and a construction subject to never-ending derangement must be resorted to, it is time to count the cost. Some users of steam engines would be very much surprised were they to do so—very much. The loss from stoppages will be too great, so great that a shovelful of coal will play a small part.

To reiterate, I do not wish to be understood as writing against any commendable effort on the part of builders and designers of steam engines to plan for a plant that in the last point shall save steam; I am no believer in full stroke, throttling engines.

When the trend is towards fairly early cut-off it is in the right direction, to be sure, but it is possible to travel too far, even when the direction *seems* right. When the manufacturer loses good orders from enforced stoppages he is likely, after a time, to conclude that there is something wrong; that perhaps he is going too far to save a handful of coal. He may reason that he would save money by submitting to a *little* plainer construction. There does not seem to be much danger of his doing this, but it is possible.

This feeling on the part of even a few users of steam engines puts many a builder at his best—at his wits end—so to speak. What some of his competitors are doing in the way of coal-saving will drive him to unrest. He has tried to make an economical engine so far as fuel is concerned—not the most economical—with reasonable attention to stability of parts and finds himself "Between the Devil and the Deep Sea." His competitors will watch the coal consumption of his engines, and criticise it, all for trade. I think there is more decency in regard to this in most European countries than here.

This builder, in self-defence, will point to his strong and reliable construction, together with good economy if it isn't the best on record, and he will have a few with him. But the great majority are still making that last lump of coal, saved at an expert test, the thing indispensable. That same last lump of coal, light as it may be, sits upon him like a nightmare. All that he says about reliable construction may be, probably is, quite true; but so long as coal-saving, saving by the ounce, is the rage, he may sing the praises of his engine and find few listeners. He must wait his time, helping to push it along.

The inventor can hardly be made to see the complication and liability to derangement of his own engine. He has sat up with it, and slept with it; he knows all about it himself, and thinks every one else ought to. You have only to keep this and that jigamaree in good order and set just right and there will be no unnecessary stopping, not if these and a few other things are done. He is honest in his views, and part of the way is right, but not always all of the way.

It is well enough to note that just as it was, the older steam engine—the engine of Watt's day—was a commercial and a scientific success. I am not of those who magnify the steam engine builder of an hundred years ago. There were too many things he did not know, but considering the mechanical knowledge of his day, and the lack of machines and tools, he did very well indeed, very well. There are too many things that the steam engine builder of to-day does not understand.

If no advances had been made in steam engineering during the past 50 years, satisfaction with that machine would have been just as great as it is now. But advances have been made, and as a result many more are expected. It is not very clear where any *great* advance is to come from, that is, especially an advance in one direction.

HEAT.

The steam engine is essentially a heat engine. Steam is merely an accident, it is the conveyor that carries the heat to the cylinder of the engine. This, the young engineer who is pulling his way along up according to his opportunities, should not fail to study.

Heat was a great stumbling block to our friends of one hundred years ago. It was believed by them to be a material substance—a rather mysterious one—that forced its way amongst the atoms of bodies, with the results noted. Later on, that is, following this universal belief in the material theory of heat, experiments were made by Count Rumford and others that would, so it would seem, have made it plain that heat was no more than a form of motion. These experiments, conclusive as they were, for some reason received very scant notice from the scientists of the day. They paid very little attention to them, and in those days scientists—philosophers—set the pace for more ordinary mortals. They were practically supreme and neglected Rumford's experiments; common people gave them no attention.

Later on, when Joule took up the matter and pushed it vigorously, it was substantially and universally accepted. The time had come when it must be accepted or thermodynamics abandoned. Finally Tyndall popularized the matter by his famous lectures upon "Heat as a Mode of Motion." There are those to-day who in a half-way manner believe in the material theory of heat, but they are few in number. To the vast majority the dynamic theory is considered as fully proven.

According to this theory, the atoms of which all bodies are composed are in constant motion—vibration—and the intensity of this vibration is noted by the thermometer and called temperature. Some of the results of the application of heat may be thus referred to: We apply heat, let us say, to a piece of cast iron. The intensity of the vibration of the atoms is increased, and the iron expands to give the atoms more room in which to vibrate. Still further heat will melt the piece, and if the heat be sufficiently intense the melted iron will be driven off as a gas.

The increased room required for the vibration of the atoms as they become hot is clearly seen in the operation of making a shrink fit. The shaft is turned larger than the hole in the piece into which it is to go. Then the piece is heated, which expands it, and the shaft drops easily to place; when the whole becomes cold—of a normal temperature—the shaft is found firmly seized. The intensity of atomic vibration has become less, hence the size of the piece is less.

Heat, then, is one manifestation of motion; it is atomic motion. It may be said that heat and motion are constantly changing places, but a given quantity of heat cannot exist in both forms at the same time. Whatever of heat goes into motion against resistance disappears as heat, and *vice versa*.

Referring again to Count Rumford's very clear dissection of what heat really was, and the scant attention given it when it was new, almost leads to the conclusion that some reason must have existed for it. Probably, however, there was nothing but laziness in the way. At any rate, if a belief in the material theory of heat had been universal up to this day, and then a new theory advanced so directly contrary as that of Rumford's, it would have the most vigorous handling, receiving not only the attention of the scientists—I do not really know who they are to-day—but of the whole civilized world, 50 years would not elapse before it was looked at. The world has advanced in that respect at least.

UNIT OF HEAT.

In order to measure the *quantity* of heat a unit must be established, the same as for any other measurement. This unit was fixed upon as the quantity of heat required to raise the temperature of one pound of pure water one degree, the water being near its greatest density, or about 39 degrees Fahr.

This is worth considering. It is a very small quantity of heat, indeed; yet Joule established the fact that this mite of heat was sufficient to raise a one pound weight to a height of 772 feet. It seems incredible but it is doubtless proven.*

This pound, raised to a height of 772 feet, is called

THE MECHANICAL EQUIVALENT OF HEAT.

The heat equivalent, Joule's equivalent and so on, is the quantity of heat required to lift one pound 772 feet.

WORK AND ENERGY.

Work in mechanics is motion against resistance. The unit of work is one pound raised to a height of one foot. It is called the foot-pound.

Energy is the capacity for doing work. One unit of heat, as

* More recent investigation has convinced the investigator that the figures should be 776 instead of 772. The difference is small, and probably Joule's authority will continue to be accepted.

has been previously stated, is the equivalent of 772 units of work.

Energy is of two kinds, kinetic and potential.

Kinetic energy is the energy of motion. Thus, if a fly-wheel is in rapid motion it possesses kinetic energy.

Potential energy is the possibility of doing work possessed by a body. If a heavy stone is placed at the top of a tall building it possesses potential energy. If dislodged it will do work in falling. There is in the stone the possibility of work.

COMBUSTION.

Heat is evolved from coal by combustion, which, in the case of a steam boiler, is the chemical combination of the combustible matter of the coal with the oxygen of the atmosphere. As in all chemical combinations, the result of this combination is heat. In the instance of burning coal the heat is quite intense. Twelve pounds of air would furnish a sufficient quantity of oxygen for the combustion of one pound of coal, if it could all be utilized. But owing to our imperfect bringing of the oxygen and combustible together in stationary engine practice, about twenty-four pounds of air are supplied the furnace for each pound of coal burned.

* * *

TOOL STEELS.—2.

B. E. D. STAFFORD.

Self-hardening steel was introduced into this country thirty years ago and was advantageously used among railroads for turning off steel tires, such as are shrunk on to wheel centers for truck or driving wheels of locomotives and coaches. By constant running and sliding, these tires, owing to the refined nature of the steel, would become crystallized in spots, due to the sudden cooling of the tire from the excessive frictional heats caused by "skidding" or sliding over the rail, and the applied pressure of brake shoes, filling the surface with fine particles of sand, causing unequal wear and subject to jars and irregularities conducive to no good results. Hence occasionally they are turned off, and no severer test can be proved for good tool steels than that of accomplishing this operation economically.

Owing to the nature of self-hardening steel, its hardness remains intact, and for that reason it is indispensable on operations of this kind, and where large steel and iron forgings and castings are to be reduced, it is the most durable, as higher speeds and feeds can be used without danger of drawing temper or softening cutting edges, which is a difficulty experienced in the use of the best grades of water-hardening steels.

The expense of sustaining tools is thus reduced to a minimum, as when a tool is properly forged it is sometimes months before it returns to the forge, continual grinding sufficient for a cutting edge is all the labor expended until the forged point is used up.

The construction of the earlier self-hardening steel, or air-hardening as it is now called, being so high in percentage of carbon and tungsten, naturally required in the mill a treatment of the utmost care and skill as to heating, mixing and hammering, necessitating a great waste of metal and careful inspection in maintaining and arriving at a uniform finished bar.

This careful process naturally places the first cost higher than most of the good tool steels now used, and has been the greatest obstacle "considered from a purchasing standpoint" to its universal adoption.

Those who have used it for years, figuring the income derived, compared to the minimum expense of sustaining tools, have found it to be the most economical steel for roughing and reducing steel prior to finishing, on all operations where the steel can be used.

Nail manufacturers use it extensively for splitting knives and headers, machine screw and bolt industries, for roughing tools in reducing stock and pointing; and in shop practice it is largely used for planing and turning, milling, facing and boring the flats, squares and rounds inserted into wrought iron discs, making a very efficient and economical tool for milling.

Of late years the process of annealing and working it into desirable shapes has been accomplished very satisfactorily, but the nature of the steel and the treatment of such being but very little known comparatively, it awaits future developments in this field, but is destined to be of great importance.

Since the introduction of self-hardening steel into this country, a great many imitations have been introduced, good, bad and indifferent, and the most important feature claimed by the originators, a point most vital to manufacturing, has been lost sight of through the disregard of manufacturers in closely following the details of expense in sustaining tools doing severe work and reducing cost of article manufactured.

This steel is the hardest of all steels under the hammer, owing to the density of the cement particles and the sustaining qualities of the structure, which prevent the steel from softening and giving way under severe work; but it can be forged, as it is, into any substantial and desirable shape successfully, or used from the bar, grinding the necessary cutting angles.

In forging this steel it is only necessary to bear in mind the nature of such, and pay particular attention to heating, using for fuel clean coke or charcoal. Heat slowly, uniformly and thoroughly to a good clear red and forge quickly, continually replacing the bar into the fire, maintaining a good even heat until the tool is completed. Do not forge at a low heat, for as the heat diminishes it becomes harder, and above all means avoid forging the end if overheated, for it is better to cut it away and proceed anew, as the cement structure of the steel is thus destroyed and no good results can be obtained, for the cutting edges will crumble.

Do not cut the bars cold, but heat them in the fire, nick well with chisel, flatten and break as the heat lowers.

Hammering the steel when it is cold causes cracks, therefore particular attention should be given when forging tools to heat them well back of the point, thereby preventing anvil jars penetrating and weakening the bar.

In hardening this steel, any degree of hardness can be gotten to suit the nature of the material worked and construction of the tool. It is well after forging to let the steel cool down, so the hammer strains will work out, then reheat for hardening slowly, keeping the hottest of the fire away from the cutting points, and when properly heated lay it aside in the cool atmosphere in a dry place, when it will harden by cooling. The lower it is heated to cool off the softer it is, and as you graduate the heat higher and then cool it off, its hardness increases. To get the best results in working extreme hard and tough pieces, this steel should be cooled off in a forcible air blast, but for large soft steel or iron forgings where the cuts are large, the tool should be slowly heated to a low red, and cooled in the atmosphere, as the speed of the work allows and the nature of the material admits, without grinding or wearing the tool away. It is worth while to consider this treatment, as in some cases it is not desirable to have the steel as hard as it would become by using air blasts, but in all cases where extreme hardness is desired, particular attention should be given to the construction of cutting angles and substantial proportioning of the tool.

To properly anneal self-hardening or air-hardening steel it should be done in muffles or boxes in the furnace, particular attention should be paid to the thorough heating of the piece and excluding air therefrom in cooling. When it is successfully accomplished, boxes filled with lime or asbestos are heated in annealing furnaces to a bright red, in the meantime heating the blanks or pieces in the forge or tool furnace slowly and thoroughly to the same heat and then introducing them into the boxes, sealed and allowed to cool down with the furnace. In working or machining annealed steel of this nature, use tools that are of the same steel, or high-tempered tool steel, using no lubricant, and satisfactory results will follow. To harden, heat slowly to a good bright red and cool in air blast; repeat the operation if it fails to become hard the first time. One peculiarity noticeable in this steel is that after proper annealing and hardening, very little or no perceptible change has taken place as regards the contraction and expansion.

The importance of this article, simply and briefly constructed, is not in the defence of any particular brand or make of tool steel, but to call the attention of manufacturers generally and their accessories to the efforts of the steel-makers of the world to give them good tool steels, tending to reduce cost to a minimum on all articles machined. In recognizing this they strike at the most economic basis to accomplish such results; and toolsmiths and machinists will see the importance of rightly working and proportioning tools to the requirements and success of steels devised for this purpose.

Successful manufacture depends on the combined efforts of all concerned, and to utterly disregard the efforts of some is an impediment to progress which is justly inexcusable.

* * *

EXPERIMENTS seem to indicate that the worm gear is not so inefficient as supposed. When the worm is made of tool steel, hardened, ground and run in oil, the efficiency is over 80 per cent.

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"Safety Valves"—R. H. Buell.
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THIS PAPER HAS THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

JANUARY, 1896.

The election of Mr. John Fritz to the presidency of the American Society of Mechanical Engineers should greatly encourage those who were not favored with a college education early in life, and whose schooling was hardly up to the average to-day. Here we find a man who has worked his way to a high position, not only in a business way but in the esteem of his fellow engineers. Starting with practically no education, he has advanced steadily and has acquired by hard work the experience and learning which enables him to fill his present position as manager of the Bethlehem Iron Works.

What Mr. Fritz has done, others can do to some extent, and by diligent work and study every man can fit himself for a better position. All cannot be managers or even foremen, but the man who has been broadening his knowledge and has kept pace with the improvements in his line will not be found at the wrong end of the procession. There is little doubt that it is harder to advance to-day than formerly, but the man who studies and works to improve himself need have little fear of the increasing competition in his line.

Do not despair because some other man has had a college education and can solve problems in higher mathematics. All problems cannot be solved with figures, and there are many cases where dependence on these alone has led to strange results and disastrous failures. Figures are of incalculable help to the mechanic when he uses them intelligently and has had experience enough to enable him to exercise good judgment in their selection and use; but without this important factor of judgement, which the college man too often lacks (as a result of little or no practical experience) the higher mathematics are not of much value. In fact one of the main qualifications for a good engineer is good judgement, and this must come mostly from experience, aided by a careful study of the work of others.

* * *

PAYING FOR BRAINS.

Those who determine the rate which shall be paid to labor in the great majority of shops do not seem to realize that brains are just as desirable in the management of the shop or drawing room as in the management of the finances of the company. The treasurer who can guard his finances so as to save a half per cent. here, or a quarter there, in some shrewd business deal is looked up to as a man to be retained at any cost and no salary within reason is too high for him to receive. In the shop it is different. The right kind of a foreman is continually saving money for the firm and in many cases actually saves many times the amount which the financial man boasts of, yet he only receives "shop pay" which seldom exceeds four dollars a day for a shop foreman and which is considered good wages. It is the same in the drawing room. Mistakes here are costly, and the brainy man in charge of this department can save more in proportion than almost any other officer or employee; yet how seldom is it recognized in a substantial manner, and we find draftsmen about as poorly paid in proportion to their work as the men in the shop. But, some will say, they cannot afford to pay a large salary; and if they cannot they should not expect a high grade of work or managing ability. The man who can save a thousand dollars a year is certainly worth more than the one who can save only a hundred, yet this is too seldom given sufficient consideration in determining the salary due.

While the demand and supply of labor largely regulates its rate of remuneration, none can deny the justice of giving each a fair share of the product of his or her labor and if a man can save you money (which is equivalent to adding to your profits) he certainly deserves a fair share of the savings.

In other words there is too little attention given to the proper remuneration of men with brains when they happen to be employed inside shop walls, and it is not an economical procedure either. Brains must be fairly paid for, or you

will be the loser in the end, as a few concerns are learning and are holding good salaries as a tempting bait to lure away the men on whom so much of your prosperity depends.

Whether the brains are in the shop or in the office, they deserve substantial recognition in proportion to the service rendered, and many are beginning to realize that recognition does not consist entirely of praise or of patents, but of a share of that "root of all evil," which is so much talked of and so little understood.

* * *

NOTES FROM NOTOWN.—6.

ICHABOD PODUNK.

Since writing and thinking about Jim Flinders and his bookselling business I recall another case, not exactly similar, although pointing in the same direction.

One of my old friends was Walter Leeds, a good machinist and draftsman and also a good manager, who was working for the Winter Mfg. Co. at the time in question.

A western concern wanted a good draftsman and designer to get up some special tools for their work, and Leeds was recommended to them. Everything went well in the negotiations until salary was mentioned, and when Leeds asked for $1,500 as a start, with more if he gave satisfaction. This ended the case, as the idea of paying a mechanic $1,500 a year and perhaps more, was not to be thought of. So they hired a young Tech. graduate at a much less salary and he started in to design special machines. Not being altogether assured of his ability, his drawings were submitted to the Winter Mfg. Co. for verification.

It so happened that these drawings were given to Leeds to examine and after a few calculations he found several glaring errors. But to avoid suspicion of being prejudiced he had another draftsman go over them with him.

The drawings had to be made over again, the plans changed, and the cost of all this far exceeded the difference between the salaries, yet it is not considered necessary to give a draftsman over $3 a day. As I have said before, it pays to hire brains in such places and if they are good ones they must be paid for at a good figure.

SOME men seem to lack a stick-to-it-ivness which is apt to be fatal to any enterprise in which they engage. There is Rodnock who used to be with the Blankety Blank Co. and whose mechanical ability no one doubted, in fact he invented the line of tools they are making and they are good tools too. He improved them before the first lot was finished and threw away all that were under way to start fresh with the new plan. This sort of thing continued until the company either had to fire Rodnock or go under themselves, and so R—— walked the plank—due to too much, or to misplaced genius.

Then he started a little shop of his own and brought out one or two good specialties which are enough to keep a shop busy if actively pushed.

These flourished for a time and all promised well until he became inoculated with the steam engine fever, which, by the way, can get away with more money and leave less to show for it than almost any line of experiments. Then the specialties, which were just beginning to be well known, had to take a back seat and the new engine, which combined the worst features of a rotary with a few good ones of the reciprocating, was launched on the steam engineering public. There were the usual bell cranks, small arms, ball joints ("wing-wongs" Mr. B. called 'em) and other paraphernalia of "the simplest engine on earth" which, according to the circulars, consisted of "a main body and a few minor parts" and which consumed steam in the temperate manner that denotes a small eater; in fact he was enthused to a high degree, as is very apt to be the case.

His regular work was directed to other channels on account of neglecting it and his only hope lay in the engine being a go—in more ways than one.

It was not difficult to place the engines, for of course they were on trial and if satisfactory would be paid for in three months. But the shop expenses keep running on even if the engine money doesn't come in very fast.

One day he came in to see Mr. B. who asked how things were going. "Nicely, Mr. B., nicely, but the money hasn't begun to come in yet. The engines are running finely but people don't seem to want to pay for them right away." "Do they run any better than their engines and use any less steam," asked Mr. B. "Certainly they do, they run steadier and as to steam, well any one can see it don't take much to run a little engine like that, and I'm sure that indicator cards will prove this." "That reminds me," said Mr. B., "of another friend of mine who invented a new valve gear for a locomotive which was sure to save steam and they took indicator cards by the dozen, both with the new and the old gear to prove its efficiency under the same conditions. The cards with the new valve gear were prettier than the others, figured up more horse power and seemed better in every way, but as I happened to be on the engine both trips I knew just how things stood. So I asked him what information he obtained from the cards." "Information! blank it, man, can't you see the increase in horse power over the old link. Can't you see how we reduce compression and get a more perfect card; can't you see—." "Oh, yes," I said, "I see the cards, the figures and all that, but were you running any faster with the new gear, when these cards were taken, than with the old gear?" "No, about the same speed, in fact a mile less per hour; but that shows how this gear increases the power when we can get this horse power at a slower speed." Ignoring this I asked; "Were you hauling any more cars than with the old gear?" "No, same number, but what difference does that make; don't the cards show a greater power and isn't that enough?" "Well, hardly," said I. "You had the same train and were running slower, yet show a greater power. Now what is the use of this extra hundred horse power if you don't get any benefit from it. If it doesn't haul any more cars or haul these any faster you are exerting this extra power to no purpose except to wear out the machinery faster. Now if you were really developing more power, which I doubt (with all due respect to the indicator), you were consuming most of it in friction in your gear, and even though it is a complicated mess, I don't think as badly of it as to believe it takes a hundred horse power to run it. Now, Rodnock, I feel this way about your engine. It will run, of course, as will almost anything if you put steam behind it; but will it run better, cost less to make and to maintain than any fairly good engine you can buy for half the money. You made a mistake in not attending to your line of specialties; they were good tools and you could have built up a good business if you had only sawed off your bump of inventiveness or put it on ice for a few years. You're like a good many others who are not content with sticking to a good thing when you have it, but who sigh for more worlds to conquer, or engines to invent."

The more I think of what Mr. B. said the more I think he is a pretty level headed man and that the inventive faculty is abnormally developed in some of our brightest mechanics, who seem to think its much better to "invent" than to manufacture. Perhaps it is—but it's the manufacturing that pays.

It may be well to close this with an incident which often amuses me when I think of it.

I was working for a man who was making a hash mixer for boarding houses, which was about as unmechanical a contrivance as I ever saw, consisting of a mess of arms and paddles connected to a crank shaft by a handful of levers. And as anything flopping around in the case would mix hash, it was a success—in his estimation.

I had never seen Mr. Mix-hasher, and one day I asked who the man was that had just passed through the room and also where he worked. Surprise and almost indignation was pictured on the face of my informant as he replied. "Work!! he's Mix-hasher, the inventor of the hash mixer—*he* don't have to work." Shades of Cæser, thought I, if the man who concocted that thing don't have to work, what would he think of himself if he invented something really useful.

* * *

A NEW method of making the teeth of rasps has been adopted by the Hoffman, Parker, Carter Co., 38 India Wharf, Boston, Mass. The teeth appear to be a series of prick punch marks in the body of the rasp and it is claimed they will not clog, owing to the cutting being done by the *outside* of the raised circular tooth instead of inside the ordinary tooth.

IN the Jones & Lamson shops, Springfield, Vt., all drawings in regular use are photographed by Mr. E. R. Fellows, the head draftsman, to the uniform size of 10x12. A print is then made which is mounted on heavy cardboard with a 2½ inch margin, allowing the drawing to be held between the thumb and fingers without danger of being soiled.

PRACTICAL TALKS ON MECHANICAL DRAWING.—(2).

LOUIS ROUILLION.

SHEET III.

PROJECTION OF SQUARE PYRAMID, 2 BY 4 INCHES.

This sheet is designed to show the proper method of projection and the relation of views.

First draw the base line of the pyramid in the front view at an angle of 30° to the horizontal and cut off the required length of 2 inches. At the center point of this base line erect a perpendicular

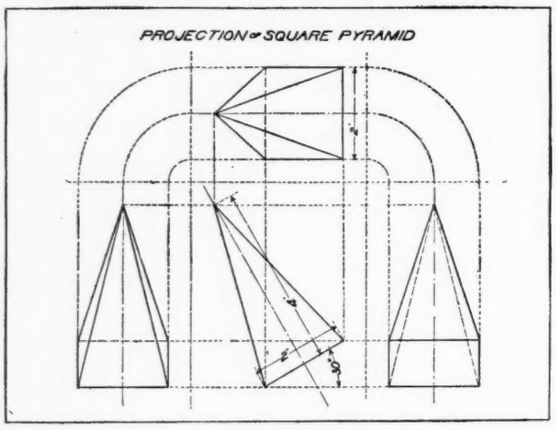


FIGURE 5.

to it to serve as a center line. This is drawn with the 60° triangle. Mark off on this center line a distance of four inches from the base line, this being the required altitude. Join the point just found with the extremities of the base line, completing the front view. At a suitable distance above this view draw a horizontal line as the center line of the top view, and one inch on either side draw lines parallel to it. Complete the foreshortened view of the base by drawing vertical lines from the extremities of the base line of the front view. The apex of the pyramid is somewhere on the center line. The point is determined by drawing a vertical line from the apex as shown in the front view, and is where this line intersects the center line. Complete the top view by joining the apex to the corners of the base.

To obtain the left hand view, first draw the vertical center line at a convenient distance to the left of the front view. This center line corresponds with the center line shown in the top view, therefore all distances above the center line in the top view are equal to distances to the left of the center line in the left hand view, and distances below the center line in the top view are equal to distances to the right of the center line in the left hand view. As in Sheet II, these relations are shown by the construction lines. For the base line, therefore, measure off one inch either side of the center line, and erect perpendiculars for the sides of the base. Cut off the required length by projecting a horizontal line from the tilted-up corner of the base in the front view. As in the top view the apex is on the center line, and is determined by projecting from the front view, and by connecting the apex with the corners of the base the left hand view is completed.

The right hand view is obtained in a manner similiar to that by which the left hand view was obtained.

In inking the drawing, show all edges that are actually seen, by full, strong lines. Where an edge is hidden by a face in front of it, show it by "hidden lines." These lines, it will be remembered, are composed of dashes $\frac{3}{16}$ inch long separated by small spaces.

Centre lines are drawn lightly, and are made up of dashes alternately one-half and one-eighth inch long. The position of center lines is first determined in making a drawing and the work is built up about these lines as centers.

The method of projection here shown is that generally used in this country. By it the top view is placed directly above the front view, the left-view to the left, the right-view to the right, and if a bottom view is required, it is placed below the front view. A few shops still retain a method of projecting views that is rapidly going out of use. By this method the top view is shown below the front view, the left hand view is shown at the right and the right hand view is shown at the left. This rather confusing arrangement results largely from the method pursued in teaching descriptive geometry. In this subject two plane surfaces are conceived, one vertical and one horizontal, at right angles to each other and intersecting in a straight line, thus forming four angles. These angles are arbitrarily numbered. Facing the vertical plane, the angle above the horizontal and in front of the vertical is called the "first angle" and the angle diagonally opposite is called the "third angle." Imagine any object placed in the first angle and lines projected from it to the two planes forming the angle. It will be seen that the projection of the front view is at the back and of the top view is at the bottom. If then the vertical plane is rotated backwards about the line of intersection until it comes into the horizontal plane, the top view will appear below the front view. This method of projection is known as "first angle" projection. If, however, while retaining the planes as before, we place the object in the third angle it will be seen that the two planes come between the observer and the object. These planes may be considered as transparent plates, so that looking down upon the object, the top view of it is projected above, and the front view in front of it. This is known as "third angle" projection and is the method almost universally taught in the technical schools. Although the "third angle" projection is much simpler for the average student to grasp, no trouble need be feared in reading "first angle" projection drawings, if it is clearly kept in mind that the top-view is not at the top but at the bottom of the front view, and that the side views are interchanged.

SHEET IV.

GROUP OF TRIANGULAR AND SQUARE PRISMS.

This sheet and the following one emphasize the method of projection. They also show how any one view may be obtained directly from two other views by projection, and how a view is rotated so as to show three sides.

A square prism, 1½ inches x 3½ inches, is inclined against a triangular prism of similar dimensions. The edge upon which the square prism rests is 2 inches back of the left hand edge of the triangular prism.

Draw the end view of the triangular prism by taking the base 1½ inches and drawing the sides with the 60° triangle. The sides will be the required length of 1½ inches. Two inches to the left draw a line that will rest upon the apex of the triangle, and cut off 3½ inches. At the extremities of this line erect perpendiculars. To do this, lay one of the triangles so that its edge coincides with the line. Hold it there firmly and bring the other triangle against the opposite side. Hold the second triangle firmly and slide the first one downwards until it clears the line at least a quarter of an inch. Its edge will be seen to be parallel with the line. Hold the first triangle firmly and bring the second around to its top edge, and by sliding the second along the top edge of the first until its 90° side embraces the extremity of the line the desired perpendicular is drawn. Then slide the second triangle along to the other extremity and draw a line parallel to the first line.

These instructions for the use of the two triangles for drawing

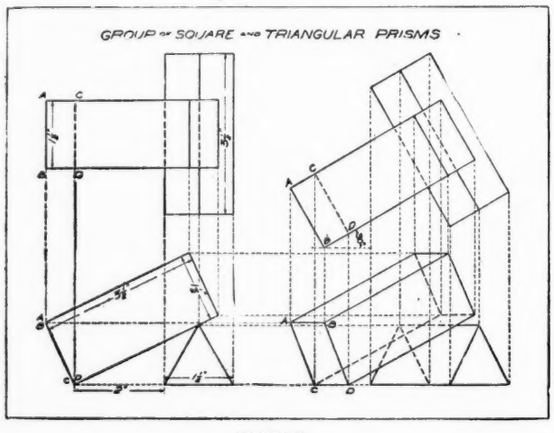


FIGURE 6

perpendiculars to lines other than horizontal should be carefully noted. It will be seen that we also have in this a method for drawing parallel lines.

We now have the perpendiculars of the square prism. On these cut off 1½ inches and draw the top line. This finishes the front view.

For the top view of the triangular prism, draw vertical lines from the vertices of the triangle in the front view, and crossing these lines draw two horizontal lines 3½ inches apart.

The center line of the square prism should cross the ridge of the triangular prism at its middle point. The top view of the square prism is obtained directly by projection. It will be noticed that the edge upon which the square prism is resting can not be seen in the top view and is, therefore, shown by a hidden line.

It is now desired to show the group turned at an angle of 30° away from the observer. This is done by rotating the top view until it forms the required angle with the horizontal. The top view at the right is an exact reproduction of the top view at the left, and differs from it in position only. It is not projected, but is drawn by taking the measurements in the dividers from the top view already found.

The front view of the rotated group is found, as shown by the construction lines, by the intersecting projections of smilar points in the lower left hand view and the upper right hand view. To show more clearly the method by which the final view is obtained, one of the faces of the square pyramid is lettered. Each letter represents the same point in each of the views. Which lines are full and which are hidden can be determined by carefully noting which faces are presented to the observer when the group is rotated.

SHEET V.

DOUBLE CROSS.

Draw the front and top views as shown at the left. For the center group, tip the front view 30° to the right, and obtain the top view by projecting similar points from this view and the top view of the left hand group. The method is the same as that used in Sheet IV. Use care in getting the hidden lines in correctly.

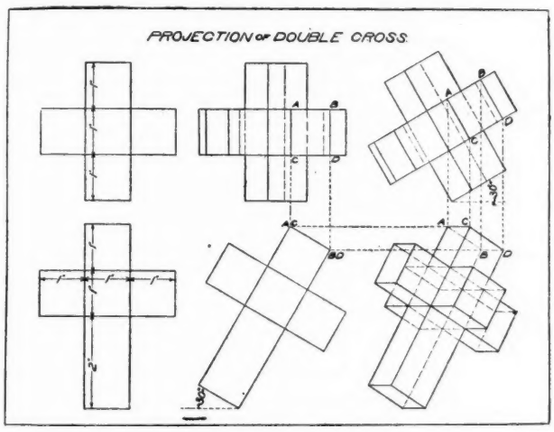


FIGURE 7.

In the left hand group the cross is shown standing erect on its base and squarely facing the observer. In the middle group it is shown still facing the observer but tilted to the right. In the right hand group it is desired to show the cross turned 30° away from the observer, while still tilted as before. The turning of an object about a perpendicular axis may be shown by turning the top view in the desired direction and through the desired angle. Therefore as we want to show the cross turned away at an angle of 30°, we rotate the top view to the left through the required angle. The final view is obtained from this rotated top view, and the front view of the center group. One face is shown projected; similar letters referring to similar angles in the various views.

SHEET VI.

HOLLOW CYLINDERS.

This sheet introduces the use of the compasses. In one leg of the compasses insert the needle-point, and in the other leg insert the pencil, carefully sharpened. In using, the legs of the compasses should be bent at the joint until they are parallel. Extra large circles are drawn by inserting the lengthening bar before the pencil or pen.

First draw the top and front views of the cylinder shown at the left, beginning with the center lines. The view shown immediately to the right of these two views is known as a "sectioned" view. Imagine the cylinder cut in halves from top to bottom. The back-half would present the appearance shown in the sectioned view, the "cross-hatching" or "sectioning" representing the cut surface. The sectioning is done by drawing a series of parallel lines about $\frac{3}{32}$ inch apart. Lay the 45° triangle on the upper edge of the T-square and draw the upper right-hand line of the sectioning. Then move the triangle to the left for each successive line. As far as possible draw both sides with one placing of the triangle. When the eye is sufficiently trained to readily estimate the distances between lines, the sectioning should be inked in without previous penciling. Various devices are in use for mechanically equalizing the distances in section-lining, but the trained eye is the most practical method.

The right hand drawing is that of a hollow cylinder with a flange about the top and bottom. In practice, when an object to be sectioned is the same on both sides of its center-line, only one side is sectioned while the other side is drawn in full. This method is here shown. In the front view the part to the left of the center line is drawn full and that to the right is drawn in section.

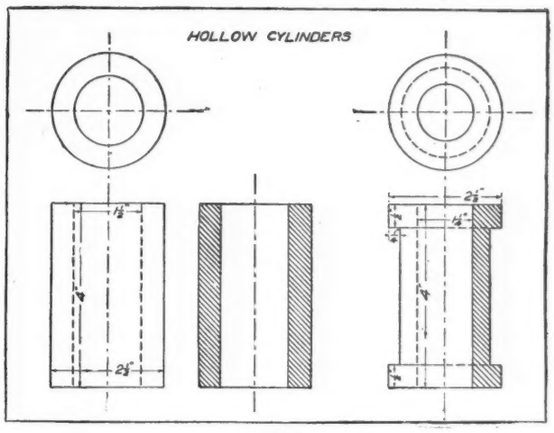


FIGURE 8.

EXERCISES.

EXERCISE 3.—PROJECTION OF A SQUARE PRISM.

Draw the front, top, and side views of a square prism, having an altitude of 4 inches, base 2 inches square, and tilted 30° to the right.

EXERCISE 4.—GROUP OF SQUARE AND HEXAGONAL PRISMS.

In Sheet IV. substitute for the triangular prism a square prism 1¼ inches x 3¼ inches, and for the square prism a hexagonal prism 3½ inches long, having ⅞ inch faces and resting on a face. Let the other requirements be the same as in Sheet IV.

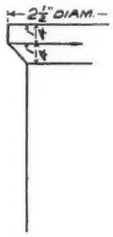


FIGURE 10

After having drawn the end view of the square prism and the base line of the hexagonal prism resting upon it, it will be necessary to draw on this line as a base a regular hexagon with ⅞ inch faces. This will serve to give the required foreshortening to the two faces of the hexagonal prism that show in this view. The hexagon should be erased before inking in the sheet.

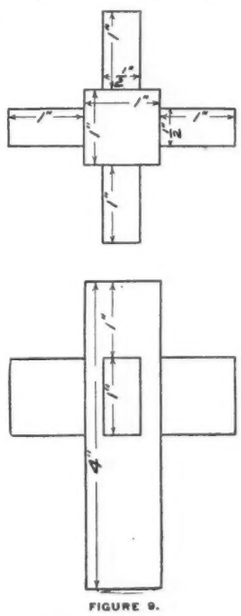


FIGURE 9.

EXERCISE 5.—PROJECTION OF DOUBLE CROSS.

In Sheet V. substitute for the cross there shown the cross shown in Fig. 9, and make the various views in the same way.

EXERCISE 6.—SECTIONED VIEWS.

Draw the top, front, and half-section of a square prism, 4 inches high, with 2½ inches base, and having a bore of 1½ inches diameter.

Also draw the top and front views of a cylinder 2 inches in diameter and 4 inches high, with bore 1⅛ inches in diameter, and having a flange at both ends. A corner of the flange is shown in Fig. 10. Show one-half of the front view in section.

* * *

Have your drawing-room and pattern-shop on the same floor if possible.

MODERN DATA ON THE PHENOMENA OF SLIDING SURFACES.—1.

JOHN H. COOPER.

Any one who studies the subject of lubrication will find himself involved in a sea of perplexities. There is no standard of measure or value for friction, its co-efficient varies with every condition of surface, pressure, kind of lubricant, velocity, temperature and other incidents, nor is it unvarying even when any selected combination of the best of these elements is maintained.

Metals in moving contact wear rapidly away on their rubbing surfaces, the effect of which is to change the character of those surfaces. The adulteration of the lubricant by this metallic abrasion begins at once to depreciate its value for lessening friction. Temperature affects the rigidity and frictional resistance of oils, while constant rubbing reduces their lubricating quality.

The first requisite for any shaft and for any metal bearing supporting the same, is that both shall be truly cylindrical, and next that they shall be smooth, with enough difference of diameters only to permit of expansion by heat without seizing contact, and of space for the flow of the lubricant to every part of the bearing.

Flat sliding surfaces and the bearings which carry them should be *truly flat;* that is, both should conform to a mathematical plane, in order to secure full bearing at every part. They should also be well supported at every part to prevent change of shape when working under load. Otherwise abrasion will begin on the unyielding parts and the surfaces for best sliding be destroyed.

For different bearing materials and different pressures, oils and grease for lubrication must be selected according as they are found by experiment to be best suited for each particular case; even then the difficulty of maintaining any standard of quality possessed by any selected lubricant must in the end defeat any adopted system, although elaborate and conclusive experiments have been made to discover what is best and how best to administer them.

During the month of February, 1891, when the writer was making experiments on journal friction, the great ease with which an axle-box could be made to slide longitudinally upon a rapidly revolving axle was noticed with much surprise. The several boxes tried had about 14 square inches of surface in contact with the axle, they were variously loaded with weights from 262 pound upwards, and the axle was running at speeds varying from 160 to 400 revolutions per minute.

One box could be slid by a pressure of one ounce when the axle was running, but required 32 pounds to slide it when the axle was still. Another box was slid by 4 ounces of a pull when the axle revolved, but required 40 pounds to slide it when the axle was stationary. A third box under considerable pressure could be readily slid by a pull of 6 ounces, but 50 pounds (the limit of the spring balance used) would not start it when the axle was still; and indeed on trial, all the muscular force I could apply to it by my hands, with my foot against the machine, failed to start it.

Here are cases, quite anomalous, where we employ forces anywhere from 160 to 1 up to perhaps 1000 to 1, for moving the same body, under the same load and pressure, no condition changed except that of the revolving or standing shaft beneath it and upon which it slides. This will happen whatever be the composition of the box or bearing, or pressure of one upon the other.

This phenomenon of friction excited the curiosity of all present who witnessed it. The temptation was great to theorize upon the extraordinary performance, but no explanation was given. Who can tell the cause of this? Is it not at least an object lesson in mechanics?

The freedom with which shafting may be moved endwise, when in rapid rotation, has no doubt been noticed by many persons whose business called them to the erecting and running of these parts of power and motion transmitting machinery.

Some of our advanced English engineers have been put to deeper thinking in their efforts to solve this riddle. I may therefore be pardoned for quoting part of a discussion upon this very topic.

"Some years ago, Mr. Hawksley, former president of the Institute of Mechanical Engineers, London, said he was puzzled by certain cases where the friction proved to be much less than had been expected. His explanation was that the friction in these cases was really 'dithering' friction, as if you frequently struck a table underneath while you dragged a weight over the top. There was then a vibration set up, so that part of the time there was friction and part of the time the weight was partially relieved, or even in the air; and he ventured to think that, whatever more scientific terms, such as intermittent friction, they might apply, this dithering friction was at the bottom of many of the unexpected differences in friction that had been discovered."

To give a practical illustration of the above, compared with a familiar expression, "everybody knows," that if loose dry sand, or like matter, be distributed over a board or level surface, that is to say, very nearly level, and then if the board be lightly tapped, the particles will gradually move "down hill," whereas without the tapping they would remain where placed; gravity here asserting itself when you give it a chance to act. But this is not a full explanation of the easy end motion of revolving shafts.

In the Huntoon hydraulic governor, the driving shaft is geared to the regulating shaft (which must have endwise motion in order that it may perform its designed function) through the means of of an idler spur wheel. Now, any one seeking to accomplish any object by machinery would naturally do it by simplest methods. An idler, therefore, added, would be considered superfluous in this machine, but experiment proved it absolutely necessary.

Endwise sensitiveness could not be secured without it: Here dithering friction came in with full permission of end motion, while the teeth of the three wheels were stepping from one to the next, and this by free and intermediate points of contact—a *dithering* condition which could not be obtained so completely by one pair of wheels. In this case the hydraulic action was a gentle effort parallel to the axis of the regulating shaft, and could only assert itself back and forth as the successive contacts of the gearing permitted.

It is said we have in the axle boxes of railway trains, which differ materially from those of shafts quietly revolving in firmly fixed or hanging bearings, a condition such that they are all in a state of vibration, which favors the flow of oil over the bearing surfaces, a dithering condition favoring lubrication, by a sort of discontinuance of contact; not so much so, however, as we have in crank-pin bearings where there is a complete reversal of pressure from one side to the other, such that good rules for safe pressure against heating and abrasion permit double the load per square inch on crank-pins as upon main shaft bearings.

Experiments on friction reported ten years ago by Mr. B. Tower, of London, developed some interesting features well worth noting: "The general results of the oil bath experiments showed, the absolute friction, that is the actual tangential force per square inch of bearing required to resist the tendency of the "brass" to go round with the journal, is nearly constant under all loads, within ordinary working limits. Most certainly it does not increase in direct proportion to the load, as it should do according to the ordinary theory of solid friction.

"The experiments on friction at different temperatures, indicate a very great diminution in the friction as the temperature rises. Thus, in the case of lard oil, taking a speed of 450 revolutions per minute, the co-efficient of friction at a temperature of 120° is only one-third of what it was at a temperature of 60°.

"A very interesting discovery was made during the oil-bath experiments, which proved conclusively that the 'brass' was actually floating on a film of oil, subject to a pressure due to the load. A gage applied to the oil-hole on top marked a pressure per square inch of over 200 pounds.

"The oil bath probably represents the most perfect lubrication possible, and the limit beyond which friction cannot be reduced by lubrication; and the experiments show that with speeds of from 100 to 200 revolutions per minute, by properly proportioning the bearing surface to the load, it is possible to reduce the co-efficient of friction as low as $\frac{1}{1000}$. A co-efficient of $\frac{1}{500}$ is easily attainable, and probably is frequently attained in ordinary engine bearings in which the direction of the force is rapidly alternating and the oil given an opportunity to get between the surfaces, while the duration of the force in one direction is not sufficient to allow time for the oil-film to be squeezed out."

In discussing the experiments, it was said that "pressures from 600 to 1,000 pounds per square inch could be depended upon without experiencing any difficulty, especially for slow speeds, and without intermittent action." We well know that for high speeds a mean between these pressures is safest, and this may be doubled for the crank pin, for Colburn, quoted the *Lady of the Lake* engine, in which the pressure on the crank-pin was shown to be 2,680 pounds per square inch.

The discussion further emphasized the interesting discovery revealed by the experiments, that, "after the load on the bearing

had risen to something like 200 pounds per square inch, the oil could no longer be fed from the top; it would not then go down, and the bearing seized immediately. But by oiling from the bottom the load had been increased up to 625 pounds per square inch, by putting on all the load that could be got into the framework of the apparatus, and at high velocities they had succeeded in running with that load." * * * "The chief advantage derived from the experiments was the showing that, if the bearing was perfectly lubricated by immersion in a bath, almost any load might be put on." To these extraordinary statements another may be added which was proven by the experiments: "That it was possible to make the brass on a journal work so nicely that there should be absolutely no metallic contact between the journal and the brass, the whole of the weight being borne by the oil. * * * "And that it was actually possible so to lubricate a bearing that not only would metallic friction be altogether done away with, and thereby the amount of power lost by friction be reduced, but metallic wear and tear would also be done away with." By giving a sufficiently profuse lubrication and by having the brasses so arranged that there should be a uniform pressure all over their surface, it was possible to have wear and tear between metal and oil, instead of between metal and metal."

The discussion further says: "This avoidance of contact by an intervening fluid was confirmed by experiments with scraped surface plates made long ago;" of which it was said: "And if air would so resist that pressure, it was much more easy for oil to do so."

* * *

EASY SHOP TALKS—GEARS.—1.

G. E. A. Ring.

In response to numerous inquiries regarding the pitch, diameter and cutting of gears, this article has been prepared with a view to making clear some of the fundamental points in regard to gear teeth, leaving the question of shape and strength of teeth out of the question.

The usual method of questioners is to ask how many teeth to give a certain size gear, or having the gear blank turned-up to say four inches in diameter, want to know how to space the teeth so as to come out even. This is placing the cart before the horse as, except in special cases, the exact diameter of the gear is the last thing to be considered. Of course we know somewhere near what they must be and work accordingly, but to make a gear the exact diameter of a blank turned by some one who knows nothing of gearology is apt to make some very peculiar pitches. To begin with the "pitch" refers to the spacing of the teeth and is used in two ways: diametral pitch and circumferential or circular pitch. The former gives the number of teeth in a gear *per inch of diameter;* this *on the pitch line.* Thus if a gear has 40 teeth and is 4 inches in diameter *on the pitch line* it is 10 pitch, because it has 10 teeth for each inch of *pitch diameter.* If having 40 teeth as before, it is 10 inches in diameter it will be 4 pitch, as it will have 4 teeth per inch of *pitch diameter.* From this we can make a few little rules that: Number of teeth divided by pitch equals pitch diameter, and number of teeth divided by pitch diameter equals the pitch. Also that pitch multiplied by pitch diameter equals the number of teeth. Calling pitch P, pitch diameter D and number of teeth N we can say:

$$\frac{N}{P} = D\ (1), \text{ or } \frac{N}{D} = P\ (2), \text{ or } D \times P = N\ (3).$$

Circumferential or circular pitch is the distance in inches *on the pitch line,* from the center of one tooth to the center of the next tooth, as from B to C in the cut. As the circumference of a circle is 3.1416 times the diameter, the relation between diameter and pitch in this case will be such that the number of teeth (N) multiplied by the pitch in inches (P) and divided by 3.1416 will equal the pitch diameter (D). Then if the circular pitch was 1.5708 inches on a large gear which had 100 teeth, the diameter will be 1.5708 (the pitch) × 100 (the number of teeth) divided by 3.1416 which gives 157.08 ÷ 3.1416 = 50 inches in diameter. Then having the diameter and number of teeth given, we can find the pitch by multiplying the diameter by 3 1416 and dividing by the number of teeth, or having 50 inches diameter and 100 teeth we multiply 50 by 3.1416 = 157.08 and dividing by 100 we have 1.5708 as the pitch. Diametral pitch is commonly used on small gears and circular on large gears, although there is no distinct line drawn and the pitch denoted should be stated, although when we say 2-inch pitch, circular pitch is meant with teeth 2 inches from center to center on the pitch line, while with 2 pitch (no inches given) 2 teeth per inch diameter would probably be meant.

Now returning to definitions we find that the "pitch line" is very vague in many minds. Let us take two iron cylinders and place them so that one will turn the other by friction, the point of driving contact will be the "pitch line." These will not drive a very heavy load, and to make them drive more, we put teeth on these cylinders and must, of course, cut out spaces between the teeth for the teeth of the opposite cylinder to fit into as they roll around. This portion below the pitch line is called the "flank" of the tooth, the upper portion or part between the pitch line and the top is called the "face" or addendum, face being the common name, although it is apt to be confused with breadth of face unless we are careful, and breadth of face, of course, means the width of the gear, the same as the width of a pulley. The distance between the point of a tooth and the bottom of the space into which it runs is called clearance, and is usually $\frac{1}{10}$ of the thickness of the tooth on the pitch line.

The first question to consider (usually) when you want to make a gear is the size tooth, as this determines the strength of the gear. Where strength is not a consideration, the size of the wheels and the pitch can be varied considerably at will.

If it is necessary to have a certain *outside* diameter on the gear, then the pitch can be more easily calculated in circular pitch, but it's an awkward job to do.

Here is a machine that calls for two gears to be 6 inches between centers, *i. e.*, the shafts are 6 inches apart, both gears to be the same size. This means that each gear will be 6 inches in *diameter on the pitch line.* Selecting a 10-pitch we have by

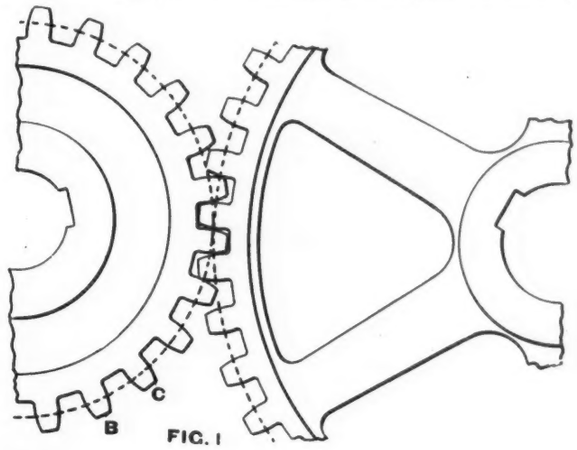


FIG. 1

formula 3, $6(D) \times 10(P) = 60$ teeth in each gear. Now the principal dimensions will be as follows:

Diametral pitch..... = 10

Diameter of pitch circle..... = 6 inches

Number of teeth..... = 60

Total diameter of gear $\left\{ = \frac{60\ (N) + 2}{10(P)} = \frac{62}{10} = \ldots = \right.$ 6.2 inches

Thickness of tooth on pitch circle $\left\{ = \frac{1.57}{10(P)} = \frac{1.57}{10} \ldots\ldots = \right.$ .157 inches

Working depth of tooth $\left\{ = \frac{2}{10(P)} = \frac{2}{10} \ldots\ldots = \right.$ .2 inches

Clearance $\left\{ = \frac{\text{thickness}}{10} = \frac{.157}{10} \ldots\ldots\ldots\ldots = \right.$ .0157 inches

Total depth of tooth $\left\{ = \text{working depth} + \text{clearance} = .2 + .0157 = .2157 \text{ in.} \right.$

These can be found for any pitch by following the above formulas in which N = number of teeth and P = pitch as before stated. Taking this same machine with centers 6 inches apart and use two gears which shall drive one shaft twice as fast as the other. This means that one must be twice the diameter of the other and have twice as many teeth, for in gears that run together the diameters or number of teeth can be considered in exactly the same way as pulleys, *i. e.*, their speeds vary directly as their diameter or teeth. Taking the same pitch as before, we can say that as both wheels had 60 teeth, or a total of 120 teeth, the new gears must have 40 and 80 teeth respectively, and as formula 1 says $\frac{80}{10} = 8$ inches for large gear and $\frac{40}{10} = 4$ inches for small gear.

Or we could have found this another way by adding the diameters of the two gears as 6+6=12, and taking one-third for the small gear and two-thirds for the larger one. This is practically all we need to do in this case, as the different proportions will be the same as the pitch is the same. Just for a little practice it might be well to calculate these for a different pitch—say 8 and we have:

Diametral pitch..... = 8
Diameter of pitch circle..... = 6 inches
Number of teeth, 8×6..... = 48

Total diameter of gear $= \frac{48(N)+2}{8} = \frac{50}{8} = 6\frac{2}{8}. =$ 6.25 inches

Thickness of tooth on pitch circle. $= \frac{1.57}{8(P)} = .196. \ldots\ldots =$ .196 inches

Working depth of tooth $= \frac{2}{8(P)} = \frac{1}{4} \ldots\ldots =$ .25 inches

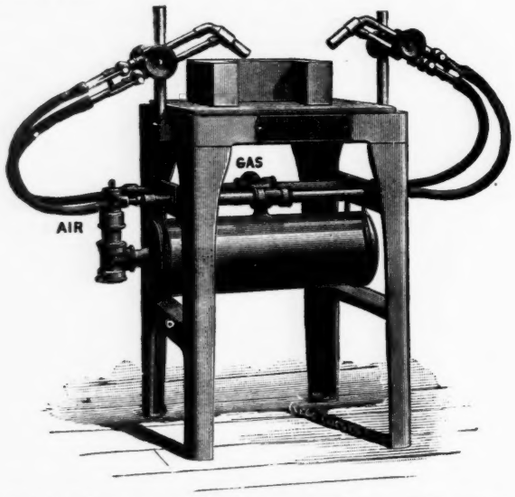
Clearance $= \frac{\text{thickness}}{10} = \frac{.196}{10} \ldots\ldots =$ .0196 inches

Total depth of tooth. = working depth + clearance = .25 + .0196 = .2696 in.

* * *

BICYCLE BRAZING TABLE.

This machine has a very large table 20×22 inches, which is covered with fire-brick 2½ inches thick. This large size of table admits of placing the work to the best advantage and leaves plenty of room for fire-brick to be placed around the parts being operated upon.



The style of burners used has been found to produce the greatest amount of heat with the least consumption of gas. The flame can be thrown in any direction desired, and both air and gas are controlled by valves, at the will of the operator.

The air reservoir is very large, and the pressure is controlled by a safety-valve, with detachable weights, and can be varied to suit the work.

Weight, as shown, 280 pounds; has a 1-inch gas-pipe and a 1½-inch air-pipe connection. Made by Perry Ransom, Oshkosh, Wisconsin.

* * *

A. S. M. E. NOTES.

The opening session was held Tuesday evening, December 3rd, and was well attended, the other sessions lasted until Friday morning. Mr. J. F. Holloway referred to the society's loss in the death of the late Mr. E. F. C. Davis, and Mr. C. E. Billings, acting president, gave a very interesting account of the development of the drop hammer, bringing it down to the present day. A solid foundation was generally recommended as opposed to the old idea of elasticity being necessary to prevent breaking of dies and hammer.

Mr. John Fritz, of the Bethlehem Iron Works, gave his experience with the large hammer at their works, and found it necessary to introduce elastic material between the anvil and foundation to protect the latter, although he thought a solid foundation preferable when possible.

Mr. Kent mentioned a cheap foundation for a hammer that was only used occasionally, which consisted of a concrete base 7 feet below the floor. A hogshead, about 7 feet high by 5 feet diameter, was built of 2 inch planks and bound with heavy steel bands. It was filled with dirt and brickbats and proved very serviceable.

Mr. Billings spoke of the tripping pins used on the drop hammers, and stated that all metal pins used had failed in a short time and they had found a remedy in hard wood. The iron and steel pins crystallized in a short time and no metal was found which would give satisfactory results.

The question of extracting oil from exhaust steam, both for utilizing the oil and for using the water for feeding boilers, resulted in rather a lively discussion. Filters of various kinds were mentioned; straw, excelsior and other similar materials being used for the purpose. One filter bed for a 2,000 HP. plant was described as being about 18x24 inches in cross-section and 12 feet long, the water passing through the 12 feet of sand to thoroughly cleanse it. Two of these are used so as to enable one to be cleaned while using the other.

The use of oil in cylinders came in for a share of the discussion, and as an example of excessive lubrication, an electric power plant in Pittsburg was mentioned where the exhaust was so full of oil as to necessitate the use of umbrellas by pedestrians to avoid soiling the clothing. Examples were also given of very successful running without oil in cylinders, Mr. John Fritz, among others, giving instances of this and expressing the belief that cylinder lubrication was carried to the extreme.

Water powers were treated by Mr. Samuel McElroy, of New York City and Mr. Samuel Webber, of Charlestown, N. H., the former dealing with the water power of the Caratunk Falls, Maine, while Mr. Webber dealt with the generation and distribution of water powers, giving a brief history of some of the larger water powers in this country, and showing the storage side of the question as well.

The calorimeter received pretty severe treatment at the hands of several of the members, and it was shown that the usual method of using the instrument was by no means certain to obtain accurate results. Mr. W. Barnett Le Van suggested that the time and money spent on making and using calorimeters be devoted to making boilers which would give dry steam instead of steam containing 5 or 6 per cent. of moisture as most of them do at present.

The friction of screws of different material with various lubricants was dealt with by Mr. Albert Kingsbury, of Durham, N. H., and presents the results of several hundred tests. In the discussion following, Mr. Kingsbury said he considered 15 per cent. a fair allowance for friction under ordinary circumstances, while in designing screws subject to rough usage and with little care he should allow 30 per cent.

The paper by Prof. Wm. F. M. Goss, of Purdue University, Lafayette, Ind., gave the result of tests of a De Laval steam turbine; which is a part of the permanent equipment of the college. With steam at 130 pounds pressure and about 2,400 revolutions of fly-wheel (turbine runs 9.90476 times this speed), the steam consumption varied from 47.8 pounds to 128.6 pounds of steam per brake horse power per hour. The engine requires very little attention, is practically noiseless and has fair regulation, due to a quick acting governor, but it will be noted that the steam consumption is decidedly higher than we have been led to expect from this type of engine.

The effect of temperature on wrought iron and steel was treated by Prof. R. C. Carpenter with tests at temperatures varying from 22 to 825 degrees, Fahr. The strength is shown to decrease from 22 to 100 degrees, then an increase until a maximum strength is obtained at 400 degrees for tool steel, 525 degrees for machinery steel and 475 degrees for wrought iron; after which the strength decreases until at about 700 degrees it is approximately at the same strength as at 22 degrees. Although the average working temperature is probably between 50 and 100 degrees, it is important to know the effect of both higher and lower temperatures on the strength of material, and it is to be hoped that they will be extended further as suggested by Mr. Gus C. Henning.

Forge shops and blowers were discussed by several members after the reading of Mr. Chamberlain's paper describing the forge shop of the Michigan Agricultural College. Mr. Woolson and Mr. Supplee both mentioned very cheap and efficient forges. In speaking of the blast, Mr. Le Van mentioned an experience of the late Mr. Geo. H. Corliss, where they connected an old blower to an underground flue four times the area of the one used before and secured a better blast, probably due to decreased friction and possibly aided by the large volume of air which may have acted as an equalizer and secured a steadier blast.

The meeting was the largest ever held by the society, the attendance being about 25 per cent. of the total membership, which, considering that the members are scattered all over this country and quite a number in Europe, is a remarkably good showing.

Mr. John Fritz, the well known manager of the Bethlehem Iron Works, was elected president of the society for the ensuing year, and when it is considered that he had but a very meagre school education and no theoretical training, it should emphasize the fact that while a technical education is to be desired, it is not absolutely essential to success.

* * *

THE AMERICAN MOULDER AND HIS ART.

PAST, PRESENT AND FUTURE COMPARED.

SIMPSON BOLLAND.

Accepting as fact the assertion that there is in this country a growing diminution in the proportion of thorough masters of the art of moulding, it may not be considered out of place if one of the craft endeavors to show the cause, or causes, to which so grave a crisis is to be attributed.

Among other reasons, some of which will be noticed as we proceed, it is often urged that our most intelligent boys are deterred from learning the trade of moulder, by reason of the mean remuneration which, as a rule, is awarded the medium and low grade classes of workmen.

As long as these boys are kept in ignorance of the actual possibilities in the case, we may reasonably conclude that all such will shrink from devoting so many of their best years to acquire a knowledge of such an apparently despicable business.

Believing this assumption to be false, and that it is based on a too cursory investigation of the subject, I hasten to correct it.

Admitting that all those who are employed upon work that only calls for the exercise of a minimum of brain force must always rest satisfied with a reduced rate of wages, we must in all fairness admit, on the other hand, that when the class of castings to be made are of a kind that only the brightest talent may be expected to execute, it is surely equitable to suppose that the maximum of remuneration must inevitably be awarded the latter.

Unquestionably the genius in founding stands apart from his fellows, and not infrequently dictates his own terms; the common men admire and pay him the deference, and his employer, while, for mercenary reasons perhaps, not too profuse in any acknowledgment of his superiority, not only pays him the highest wages, but is careful also to retain his services when, for reasons of economy, men of an inferior stamp are peremptorily dispensed with.

The natural consequence of employing men of marked ability and sterling worth, is an almost entire exemption from badly finished and totally bad castings, and where the opposite effect obtains it may, in the great majority of instances, be traced to a want of just such qualities in the men they employ.

Employers would fain withhold their acquiescence in the truth of the above, yet we know that many of them are fruitlessly endeavoring to accomplish tasks that are completely beyond the capacity of their incompetent and poorly paid help.

The ambitious apprentice moulder who intelligently grasps these truths, will readily understand that if he thoroughly qualifies himself, he may in the end not only command a high price for his labor, but receive recognition such as is accorded to no other artisan in the metal industries.

The boy who purposes to graduate as an expert must not disregard the fact that moulding in its highest signification cannot be reduced to an exact science, as it were, and learned with the same facility as the multiplication table, as some of our too superficial critics would have us believe. Such of us as have devoted a lifetime to its pursuit know that besides all the mechanical difficulties to be surmounted by new and original means, invariably, on nearly every change of job, there are manipulative and artistic effects to be wrought out that will be looked for in vain if the trained artist has been absent.

Thorough moulders, like great sculptors, must have inspiration and ambition, as well as a perfect knowledge of detail. There are moulders who cheerfully devote their entire lives to the accomplishment of the work it is their highest ambition to produce.

The commonplace and less ambitious are satisfied to copy the above named artists, but of course the measure of their success can only be in proportion to their ability to remember how the various operations were performed that finally resulted in the master's first successful achievement. Too frequently this false system terminates in dire disaster, as all experience based on such shallow practice must.

When a competent moulder undertakes to produce a casting of magnitude, the true artist feelings at once possess and control him. Wedded to his art, as it were, he carefully surveys his plans and sketches, and proceeds mentally to construct a mould about them, that shall meet every requisite for the production of a perfect casting. His superior knowledge of technique and profound discrimination aids him in grasping every difficulty intelligently, so that after the foundation of his job has been laid, every subsequent operation serves to heighten the interest in his labor, and effectually robs it of all that would otherwise tend to make it monotonous.

Let it be noticed just here that a successful moulder must, besides the special gift of genius before spoken of, be in all respects a constructor of the first order. A mould must possess absolute rigidity, although the materials entering into its construction are in themselves very deficient in that quality; therefore, in planning the several sections into which some moulds must necessarily be divided, and in the arrangements for their safe transportation, a more than ordinary knowledge of mechanics must enter into the sum of his qualifications.

To what extent a thorough scientific training enhances the value of such an artist may be readily conceived, yet, with comparatively no knowledge of chemistry or the sciences, our progenitors have long ago discovered (besides many other shrewd devices) most of the safe contrivances for conveying dangerous gases from the moulds, and any improvement would be difficult to suggest. Notwithstanding the numerous obstacles that beset them, they have nobly overcome all the perplexities and dangers incident to conveying large quantities of molten metal, and retaining the same in every description of mould.

Long before the chemist became a factor in foundry economics, the moulders of the past had discovered nearly all the materials suitable for the production of smooth, sound castings, evidences of which may be found in almost all parts of the earth.

Just here the question naturally arises, are there men of this class in existence to-day? I answer yes, but their number is gradually decreasing. The causes for this are not far to seek, and it will indicate a wiser policy than has hitherto been manifested, when a larger number of those directly interested in this question have been persuaded to view it from the same standpoint as the writer.

Recognizing the fact that true genius must enter into the composition of reliable moulders, how ridiculous to suppose that any scheme other than the assiduous and protracted early training of our boys in the art, will succeed in meeting the demand for this class of workmen in the future.

No reliance can be placed on many of the slip-shod systems of apprenticeship now in vogue to meet this emergency. This is a serious question that must be met with due gravity, the terms of the indenture must be binding, and the parties to the contract should be taught the importance of a firm adherence to every stipulation contained therein.

Boys who have contracted vicious habits, and persistently followed them up to the age of fifteen or sixteen, are in most cases really unfit for the stringent course of study and application needed to make good moulders; with such, the yoke soon galls, and they strenuously oppose all legal restraint as being, in their foolish estimation, a violation of their rights as free-born Americans. Forgetting the object in view, boys of this caste become disagreeable, if not mutinous, and are usually left to their own

evil devices, with the unhappy result of eventually leaguing with the many discontented failures our trade is infested with.

The scarcity of efficient moulders is not by any means confined to high-class machinery foundries, from all quarters, even among the stove and architectural works, this woeful refrain is heard. Naturally, these special branches of founding, owing to the growing scarcity of high-grade machinery moulders, are now thrown more upon their own resources; they miss the leaven which formerly flowed that way at periods when good machinery moulders were plentiful and would be occasionally tempted to take a spell at stove or house work, when piece-work rates at these foundries offered inducements for extra pay. Many of these men were encouraged to stay on at special rates, for a time at least, and the correct methods pursued by these superior minds were naturally copied by their less intelligent fellows with a considerable degree of success.

It is gratifying to observe how effectively, one after another, the hallucinations regarding moulders and moulding are being exploded; this augurs favorably for the best interests of both artizan and employer. The fear of a dearth of good workmen, with its concurrent train of evils, is prompting a laudable inquiry in high places; they are fast discovering that moulding consists of more than simply taking an impression in sand and filling the space with molten metal. While the general knowledge of so noble an art was limited to the above quoted theory, there was certainly small encouragement to hope for improvement. Acting upon such false and misleading premises, many of our minor founders have unadvisedly inaugurated a system of promoting their advanced laboring help to the position of moulders, and this irrespective of either age or education. Is it any wonder that at these places there should be ruinous waste, and an uproaring clamor for better men.

It has often been attempted to utilize stove, architectural, hollow-ware and other classes of moulders to make good the deficiency now existing in the number of skilled machinery moulders. Any extended attempt in this direction almost always ends in failure, simply because, ordinarily, such men have had no experience beyond the piece they were taught to make parrot-wise, and are therefore altogether unfit to accommodate themselves to a pursuit that, to be perfect in, demands uninterrupted study and practice from the youth up.

Some presume that the scarcity of good moulders is to some extent caused by utilizing such for managers and foremen; this conjecture may hold good in isolated cases, but it undeniably is not the rule. Very many of these positions are held by wholly incompetent men, who were fortunate in having some influential friend, or friends; but in order to maintain their positions, managers of this type must necessarily engage talented men at the highest rates, thus adroitly covering their own deficiencies at the expense of an unsuspecting employer.

True, there are some of our leading moulders who combine with high artistic ability the commanding qualities of an executive nature; many such men are justly marked and naturally gravitate to good positions; but the great majority of our brightest men are too entirely absorbed in their calling to permit of any change that would debar them from a display of their artistic abilities. Besides, it is a notable fact that this class of men are usually of a generous nature, receive sometimes as much pay as their foremen, and prefer to enjoy absolute freedom from all responsibility other than legitimately belongs to the particular job they are engaged upon.

Years ago, our chief marine and jobbing foundries in the principal Eastern cities depended largely on the constant influx of good moulders from European countries for their supply. The best of these workmen found no trouble in settling down to steady employment at good wages as soon as they arrived. Of course many, both capable and otherwise, pressed inland, so that for many years this steady flow of foreign talent was being absorbed in all directions, to the special advantage of those who were fortunate in securing moulders who had been thoroughly grounded in their profession before they sought our shores. An emigration fund, subscribed by the "Friendly Society of Iron Founders," was the means by which large numbers of British moulders were enabled to cast in their lot among us. The Scotch society too, if I mistake not, helped, during hard times, many of their nationality to emigrate this way. The object in this scheme was two-fold, for while the poor moulder was personally benefited by the transfer, a glutted labor market was just to that extent agreeably relieved.

This once fruitful supply of ready-made moulders enabled us to run our foundries on the old time-honored lines, viz., that almost every man was well capable of moulding any casting in his line, without aid from either shopmate or foreman.

If you ask how castings are now being made under the less favorable auspices, I refer you to almost any of our foremost establishments throughout the States, where you will find that if twenty-four men are employed on massive loam and dry sand work, they will be cut up into gangs, each led by a master mind, who directs every operation employed on the job. It is no uncommon occurrence to find cases where one man has charge of two or more jobs; a little increase in pay is, of course, the inducement for this genius to duplicate himself after this manner. This system, owing, as before stated, to the growing deficiency in the number of skilled machinery moulders, is fast assuming a permanent shape in almost all foundries; the few leading men to be obtained must mould the first of every important casting, in order that the plan of moulding, tools and rigging shall be of such a character that will assure success, even with subordinate help, should the leader be transferred to another job in the meantime; a contingency for which he is expected to hold himself in readiness. The absence of these superior men is invariably indicated by the advent of bad castings and generally inferior work.

How all this affects the able and conscientious foreman need not be dwelt upon here, as almost the least informed may readily conceive the difference betwixt the latter mentioned state of things as compared with the time when well trained moulders were plentiful.

The growing popularity of the moulding machines and divers other contrivances of the genus *match-plate*, need not be feared as in any sense affecting this question of the supply and demand of good moulders. Such improved methods have been gradually evolved out of the natural order of things, the wonder is that, with all our boasted mechanical advancement, even better contrivances than at present exist are not more generally in use. We should by no means withhold any of the credit due them; whatever comes within the range of their capacity is done well, for the simple reason that when once the rammers have been precisely adjusted, every similar casting is a true duplicate, a highly desirable feature whether in machine or hand moulding.

While we must admire all the ingenuity displayed in this direction for a more accurate as well as more rapid delivery of a limited range of castings, I am firmly persuaded that, in so far as such means are ever likely to usurp the place of the legitimate moulder, there is not the least occasion for alarm, and no one need look in that direction anticipating a time when machines can be employed to fill the gap that is now so unmistakably apparent in the ranks of our skilled workmen.

There are those who claim that the old method of training moulders by serving an apprenticeship is made impossble in foundries where, owing to keen competition, every advantage must be taken which the system of dividing labor offers, in order to obtain the best possible output. Constant practice on the same piece conduces, as we know, to rapidity of motion, and as the mind is wholly concentrated on this one piece, everything naturally conspires to a perfection in practice positively unattainable by any other means. All this is very complete, no doubt, so far as it relates to rapid production, or the mercenary side of the question; but even where such practice is possible, some modification of the system is imperatively demanded if it is desired to maintain the requisite standard of excellence in the moulders they employ. Have we not strong confirmation of the truth of this assertion in the fact that even now there is an acknowledged steady deterioration in quality of castings produced after this manner.

We owe it to our race and profession to render some service thereto, and stigmatize as cold-blooded and inhuman any system that tends to degrade an honorable calling. Are we not doing violence to our better nature when we consign our boys to a system of training that leaves them in almost entire ignorance of the trade they believed they were learning? Yet we enact this cruelty constantly, heedless of the enormous sacrifice, and are content with the ignoble result that larger dividends may be declared by some already bloated corporation. But observe how beautifully nature, in this instance, asserts her inexorable laws; extracting all and rendering nothing in return, this heartless and suicidal course has resulted in entirely banishing from our foundries the very element necessary for their preservation. To

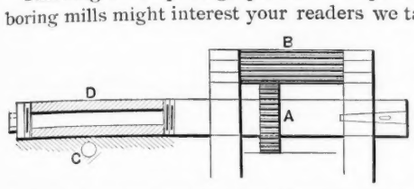
assist in the moral elevation of his employes is the duty of every employer of labor. How much existing methods tend to degrade the artizan is self-evident, and it is equally as evident that the laws of reprisal has in this instance a forcible illustration, for if during the past years some rigorous system of apprenticeship had been enforced, whereby a boy could have mastered, at least, all that was possible to be learned at the firm he was apprenticed to, we should, without question, have been spared this humiliating outcry for better moulders of all classes; and all this at a cost that pales into insignificance compared with the mighty gains so wise a procedure would have engendered.

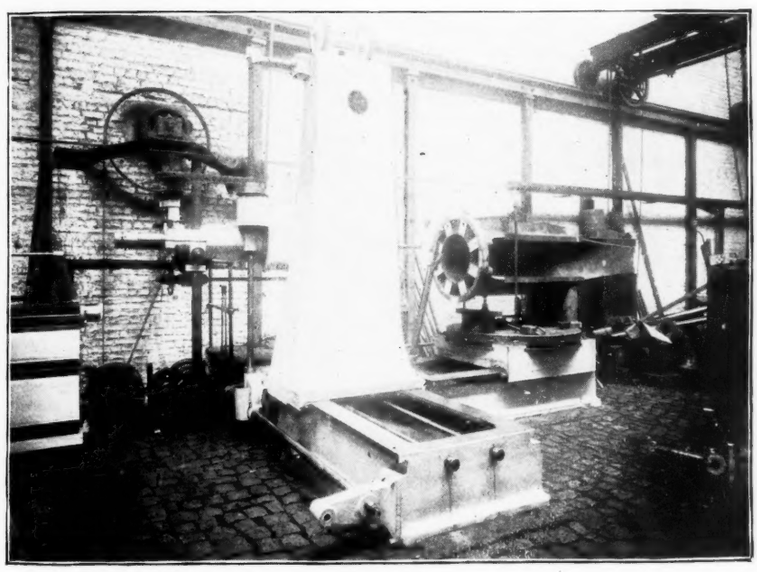
* * *

A HANDY BORING MILL.

A. Bollinckx.

Thinking that a photograph and description of one of our large boring mills might interest your readers we take pleasure in giving them. It is adapted to a large variety of milling, drilling, boring and tapping, the latter operation being facilitated by the use of a motor having a double commutator which can be readily reversed for backing out the tap. Contrary to the usual construction of this style of machine, the arbor passes through the whole tool holder, which was done to secure greater stiffness and proved successful. The gear A is keyed on the arbor which is driven by the long pinion B, while the spindle is moved by the gear C working in the rack on the sleeve D.





A HANDY BORING MILL.

The circular table is 1.3 meters in diameter, and the machine can take a piece of work 1.5 meters high by 2 meters in length. All the feeds are by power and automatic.

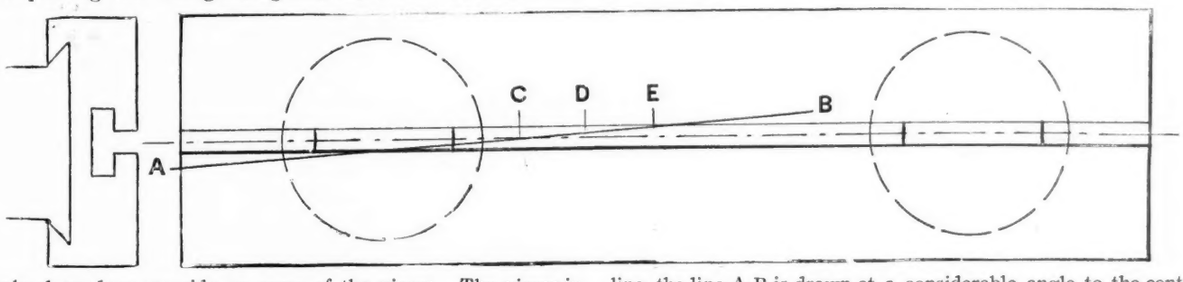
* * *

LOOKING AFTER LATHE CENTERS.

It all came about through the man who ran the grinding machine complaining that the grinding allowance was too small, as it only cleaned up one side on some of the pieces. The pieces in question were short shafts or pins varying in diameter from ¾ of an inch to 2½ inches, and in length from 6 to 18 inches, the allowance for grinding being .002 inch on a side, .004 inch in all; ample if everything is in good order and the piece will run exactly the same on the grinder as it did on the lathe; but here was where the trouble came in. After finding that the pieces would not clean up to the required size, but that all the grinding came on one side, the lathe centers were looked into. Lathes that were supposed to be exactly alike did not have the same taper for the center in spindle. Centers, which are made in quantities and fitted to spindles with points left blank, were found not to fit the lathes they were intended for, and the centers in use did not exactly fit their spindles, so that an extra pressure or a lifting action of the center in the work will change its position and with it the truth of the work with relation to its centers, making it eccentric to a slight extent. This condition of the centers not fitting their spindles may have been due to improper fitting at first or to lack of care in seeing that both the center and the spindle were clean before putting in place. A continuance of this kind of work will demoralize any self-respecting center, and is not good practice. A spindle should be protected from dust and chips by a piece of clean waste when no center is in place, or a cork makes a convenient dust cap. When a center *fits* the spindle and both are clean, you can hear a peculiar sound when the center is put into place, that cannot be produced in any other way; this tells the mechanic whether the center fits or not.

This state of affairs would not do for a shop which has a reputation for the best of work, and it must be remedied, so the only thing to be done was to overhaul the spindles first and the centers afterwards. A reamer was made which would just clean out the largest spindle, and a gage was made and reamed for a standard, a taper plug being hardened and ground to fit the gage. This was the beginning, and the next step was to ream all the spindles to new standard. After this the centers must be reground to the new gage before everything was in good order once more. This took time, patience and extreme care, and this developed several faults in the grinder which it will be well to call attention to. When grinding the new centers which were kept in stock there was little trouble experienced, as they were all the same length and with practically the same depth of countersink, as after getti g the machine right for one it was all right for the rest. When it came to grinding the straight portion of the centers or any straight piece where the lengths varied, it was impossible to get the pieces straight without resetting the machine for each length of piece to be ground. This indicated that everything was not in line with the grinding machine, and as it was a good machine and of standard make, it was closely investigated to discover its faults.

Fig. 1 shows an outline view of the table, and as the wheel is stationary, there is no need of showing that. The slot through the center of the table was not scraped or ground, and the heads holding the centers did not fit this slot as the quality of the work demanded, and there was an appreciable looseness between the tongue under the head and the slot, so that even when clamped down a light blow on either end of head would affect the truth of the work. For work of this kind there should be no shake whatever, and the bearings under each head should be ample to prevent this as well as appreciable wear. To sh w the effe t of not having one of the spindles absolutely in line, the line A B is drawn at a considerable angle to the center line to exaggerate the case and to clearly show the effect of not having the center absolutely in line with the slot in which the

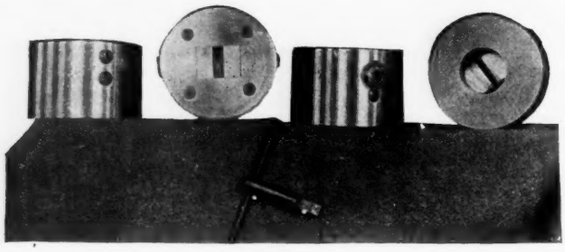


head moves. If the center is advanced to the line C, the work will be in line with the other center and can be ground without any trouble. A shorter piece may advance the center to D or E, and it can be readily seen that this will affect the work by shifting one center so as to make the work taper. This indicates that although the machine can be adjusted to correct the errors, the centers should be absolutely in line with each other and in line with slot in which they are clamped, and that this should be scraped and fitted so as to be true its entire length and hold the heads solidly in line when clamped to place. The work is going on smoothly once more, the centers *fit* the spindles, the new centers have been reground, and it is hoped some time will elapse before this bugbear again disturbs us, and that the grinders we buy will be better than the last. A. R. T.

* * *

A NEW CHUCK.

These are independent jaw chucks with a plain reamed hole in the back end so customer may thread them to fit their lathe spindle. The jaws are two plain blocks of tool steel held in position in the chuck body by a thin cast iron plate attached to the body of the chuck by four fillister head machine screws. One jaw is



backed up by two machine screws which are slotted for screw driver; the advantage of two screws is in keeping the jaw from tipping either at top or bottom. The other jaw is operated by a single screw which has a square hole suitable for key wrench.

The new feature of this chuck is a hardened steel bushing through which this driver passes, so that after the screw (which is in constant operation) becomes worn, it can be easily replaced, and even if the steel bushing in which it operates becomes worn, that can be replaced at a trifling expense, while if the screw which operates the jaw were to be operated in the cast iron body, the thread in the chuck body would wear out even before the screw.

The small machine screw shown below the bushing has a slight bearing in the bushing to keep it from turning when the screw is operated. The jaw screw which is operated by the wrench is placed about midway between the two screws which support the opposite jaw. It will readily be seen that when the chuck has once been adjusted to certain size work, that it is only necessary to tighten and loosen the one screw to hold the work. This has been found a very convenient style of chuck, and is strong and durable. They are made by the Skinner Chuck Co., New Britain, Conn.

* * *

BORING AND TURNING MILL.

The engraving herewith shows the improved Boring and Turning Mill as recently gotten out by the Betts Machine Company, Wilmington, Del., U. S. A.

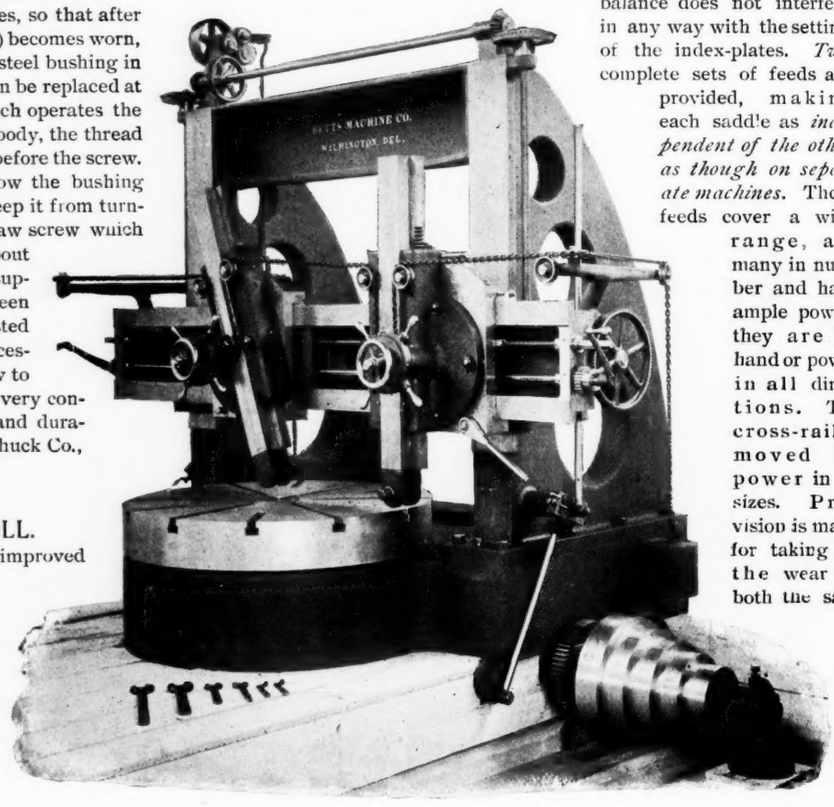
The mill is stiff and heavy in all its parts, and is conveniently and rapidly handled. It has the advantage of large ratio of gearing and large cone; of the large number of speeds of table; of the positive and entirely independent feeds and of the perfect counterbalance to each spindle. The bed-plate is of box form, of heavy section, well braced with ample flanges, and has the gearing for driving the table firmly secured thereto.

The table is driven by an internal spur wheel and a forged steel pinion, and is attached to a stout and long spindle at its center. The spindle is carried in an adjustable bearing in the bed-plate, while its lower end rests on a steel step and wedge enclosed in another adjustable bearing. On the bottom side of the table is an annular bearing which is a part of the bed-plate, for the sustaining of heavy loads on the table; when light loads are being handled, the wedge under the bottom step can be pushed in by operating a square-ended rod in the bed-plate beside the table, thus raising the table off the annular bearing, allowing it to run lightly for faster speeds. The table is well provided with T slots to secure work.

The driving gears are all cut from the solid, and all spur pinions are of forged steel. The pitch and face of the gears are large and have proven very successful in wearing qualities and strength. The driving shaft is of large diameter and runs in long bearings. The driving cones are provided with a convenient number of speeds and generous belt width.

The uprights are of the box or double plate pattern, have wide faces and long bases. They are amply secured with bolts which fit in T slots in the side pieces of the bed-plate, thus allowing the mill to enlarge its swing. The front ends of the uprights are provided with taper dowels to bring them into alignment again after being moved.

The cross-rail is made deep in its bearing on the face of the uprights and is secured thereto by a long clamp extending its full depth. It is of heavy box section with large wearing surface and has a square lock for the saddles, both top and bottom, thus always taking the strain in a manner to best resist wear and spring. The saddles have a long bearing on the cross-rail, with rapid hand movement by rack and pinions; the face of the saddle is provided with a circular T slot, which receives the bolts, and these secure the index-plates or swivels. The index-plates carry the tool spindles or cutter bars in a slide on their face, and these are also provided with a square lock, as in the case of the cross rail. The tool spindles are provided with a rack and pinion for quick motion up or down, as well as for feeding; the ends of the spindles are provided with a special tool-holder, in which the tool can be fastened and adjusted with as much ease and as great scope as in a lathe. *Each* spindle is counterbalanced in *all* positions, and the counterbalance does not interfere in any way with the setting of the index-plates. *Two* complete sets of feeds are provided, making each saddle as *independent of the other as though on separate machines.* These feeds cover a wide range, are many in number and have ample power; they are by hand or power in all directions. The cross-rail is moved by power in all sizes. Provision is made for taking up the wear in both the saddles and tool spindles. Complete details may be had of the makers.



* * *

If Mr. H. S Brown, who wrote us some time ago, will send his address, we shall be pleased to comply with his request.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

A LITTLE MENSURATION.

CALEB TOPHAM.

As we have become familiar with the operations of square and cube root, we are prepared to attack almost any problem which may come up in shop work, and they are coming up every day. Sometimes a man contents himself with wishing he knew how much a certain piece weighs, sometimes he asks a draftsman if he can figure it out for him, and then he wishes he knew as much as the draftsman.

In the November issue we did a little of this work and a little more may be of interest and helpful in becoming familiar with the methods and rules used.

Having a cast iron turret 12 inches in diameter, 6 inches deep, a 4 inch hole through center and containing six 2 inch holes, what will be its weight?

The easiest way will be to calculate its weight as if solid, then deduct the openings, and though a little tedious it can be done very easily. As the area of a ring equals the diameter squared × .7854, we have $12 \times 12 \times .7854 = 113.09$ square inches. This multiplied by the depth gives the volume in cubic inches, and $113.09 \times 6 = 678.54$ cubic inches supposing it to be solid.

Deducting the center hole first we have $4 \times 4 \times .7854 = 12.56$ and multiplied by $6 = 12.56 \times 6 = 75.36$ cubic inches in the hole.

Now the holes are not as long as half the diameter of turret, as there is a four inch hole in center, so taking 4 inches from 12 inches leaves 8 inches as total thickness of metal, or 4 inches each side. Area of each hole equals $2 \times 2 \times .7854 = 3.14$ square inches and multiplying by 4 gives $3.14 \times 4 = 12.56$ cubic inches in each hole. As there are six holes we multiply 12.56 by 6 and have 75.36, which happens to be the same as the contents of the center hole.

It may seem strange to say that 6 holes, 2 inches in diameter and 4 inches long, contain no more volume in cubic inches than one hole 4 inches in diameter and 6 inches long; and rather than have any confusion in the matter it will be better to look into it carefully.

It will, perhaps, be easier to imagine the six, 2 inch holes joined end to end making a 2 inch hole (never mind what makes the hole, 6×4) 24 inches long, or four times the length of the 4 inch hole. Here is where the "law of squares," that was mentioned before, makes itself evident. Taking the two diameters and squaring them, we have $2 \times 2 = 4$ and $4 \times 4 = 16$, showing that, as 16 (the square of 4) is four times 4 (the square of 2), the area of a 4 inch circle is four times the area of a 2 inch circle, and it is evident that if a 2 inch hole of the same length is only ¼ the contents of a 4 inch hole, a 2 inch hole four times as long will be equal to it.

Continuing with the turret, we have to deduct $75.36 + 75.36$ (center hole plus six tool holes) $= 150.72$ cubic inches to be deducted from 678.54, $678.54 - 150.72 = 527.82$ cubic inches of cast iron. Taking this at .26 of a pound per cubic inch we have $527.82 \times .26 = 137.23$ pounds. As the main thing about estimating weight is to know the contents, and, as in most cases, it is necessary to find the area of one or more surfaces before finding the contents, it may be well to look into this feature of the calculation more thoroughly. This is not exactly going backward, for as far as we have gone we have only dealt with plain surfaces and have calculated them as we went along.

The sphere or ball is always attractive and a few formulas concerning this will be interesting and will also give good exercise in making calculations.

The radius of a circle (or distance from center to circumference) of course equals half the diameter, and as this term is sometimes used in formulas it is well to be familiar with it. Taking the regulation formula for the surface of a ball we have: $D \times C = S$, where D = diameter, C = circumference and S = surface. As the circumference is found by multiplying the diameter by 3.1416, this rule amounts to saying $D \times D \times 3.1416 = S$ as we shall see. Taking a 10 inch ball we have by first rule 10 (D) × 31.416(C) × 314.16 square inches, or 10 (D) × 10(D) × 3.1416 = 314.16 square inches of surface.

Transposing to find the diameter of a ball whose surface must be 512 square inches, we reason that if the area (as in the last case) equals the diameter squared and multiplied by "pi" or 3.1416, then if we divide the area by 3.1416 we shall have the square of the diameter, and by extracting the square root of this we have the diameter. To be sure of this let us try the example we have already taken and, having a ball with an area of 314.16 square inches, we divide this by 3.1416 which gives 100 as square of diameter. Square root of 100 equals 10, the diameter. Knowing the rule is right we try it with the ball having an area of 512 square inches. Or $512 \div 3.1415 = 162.9$. Then 162.9 equals the *square* of the diameter, and taking the square root of 162.9 we have 12.7 inches as the diameter of the ball.

It is sometimes necessary to know the volume of a ball, as in finding its weight or the amount of liquid or gas that a hollow sphere will contain.

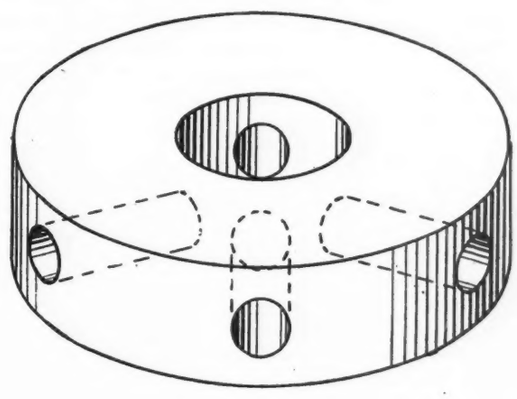


FIGURE 1.

The rule is: Cube the diameter and multiply by .5236. Taking the 10 inch ball again we have $10 \times 10 \times 10 \times .5236 = 523.6$ cubic inches, and the weight can be found by multiplying this by the weight *per cubic inch* of the material of which it is composed; if cast iron by .26, if steel .283, if lead by .41, or if gold by .695 as the case may be, as given in the note book in the September issue.

As we have to deal with cones and pyramids to a limited extent, it will not be amiss to touch on this phase of the calculations. Taking a cone, such as a large cone lathe center for hollow work, we can find its curved (or convex in this case) surface by multiplying the circumference of the base by half the *slant* height, or length of slanting side. If we have a center which is 4 inches in diameter at the base and measure 5 inches along the slant side, the curved surface will be $4 \times 3.1416 = 12.5664 \times 2.5$ (½ of 5) = 31.416 square inches. If the entire surface is to be obtained; find the area of base (diameter squared × .7854 or $4 \times 4 \times .7854$) making 12.5664, and add to this. Adding $31.416 + 12.5664 = 43.9824$ square inches total surface.

It often happens that these large centers do not end in a point but are cut off to shorten them until the top is flat to a diameter

of say 1.5 inches. This makes the center what is called a "frustrum" of cone and the rule for the curved surface is: Add the circumference of both ends and multiply by half the *slant* height as before. The circumference of the small end will be $1.5 \times 3.1416 = 4.71 + 12.56$ (which we found before) $= 17.27$ as the sum of the circumference of each end. Calling the slant height 3.5 inches, we have 17.27×1.75 (half of 3.5) $= 30.22$ square inches, only 1.2 square inches less than with the entire cone. As the slant height is not always given, the vertical height (distance from the center of base direct to point of cone, or to center of other end) being often the only figure obtainable, we must be prepared by learning how to find either the vertical or slant height, having the other height and the base given. This is found by considering the cone (in section) as a right angled triangle and calculating as though dealing with them.

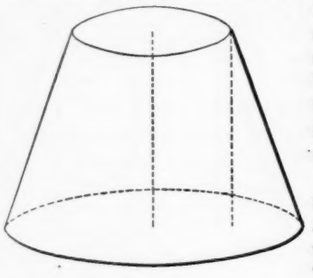


FIGURE 2.

The slant height (or hypothenuse) equals the *square* of the *sum* of the *squares* of base and vertical or perpendicular side.* That sounds hard, but let's work it out with an easy case. Take a right angle triangle having a base of 3 inches, vertical height 4 inches, what is the slant side? The base is 3 inches and height 4 inches, then $3 \times 3 = 9$, the square of the base; $4 \times 4 = 16$, the square of vertical height. Then $9 + 16 = 25$. As this equals the square of the hypothenuse, the square root of this number will be the desired figure, and the square root of $25 = 5$ the slant height or hypothenuse. In formula language we say:

$$\text{Slant height} = \sqrt{\text{base}^2 + \text{vertical height}^2}$$

or calling base B, vertical H and slant S:

$$S = \sqrt{B^2 + H^2} \quad (1)$$

and to find either of the others we transpose and say:

$$B = \sqrt{S^2 - H^2} \quad (2) \text{ and } H = \sqrt{S^2 - B^2} \quad (3).$$

With a cone 4 inches in diameter at the base, it is plain that a center line from the point would make a triangle having a 2 inch base, and as the slant height was given as 5 inches in the first case we must use the last transposition of formula to find the vertical height and we have

$$H = \sqrt{S^2 - B^2}$$

or as $5 \times 5 = 25$ and $2 \times 2 = 4$ gives

$$H = \sqrt{25 - 4} = \sqrt{21}$$

(as both numbers are included under the bar) or 4.58 as vertical height.

In the case of a frustrum of a cone we can drop a line (in imagination) from the edge of the upper surface to the base, and from the point found to the outer edge of the base gives the base of the triangle. Taking figure 2, which we will say has a base 6 inches in diameter and is 2 inches in diameter at top, with a slant height of 7 inches. Half the diameter of base, minus half the diameter of the top gives the base of triangle formed as mentioned before, and we have: ½ of 6 = 3, ½ of 2 = 1, 3 − 1 = 2 as the base. As slant height is 7 inches we have

$$H = \sqrt{49 - 4} = \sqrt{45} = 6.7 \text{ as vertical height.}$$

The base can be found in the same way by using the second formula given. These can also be applied to many other problems as, for example, a ladder 50 feet is placed against a building with its top 40 feet from the ground, how far will the bottom be from the building? This takes formula 2 and we have

$$B = \sqrt{S^2 - H^2} \text{ or } \sqrt{50^2 - 40^2} = 2{,}500 - 1{,}600 = \sqrt{900}$$

= 30 feet distance from foot of ladder to wall of building.

* * *

With few exceptions the success of small shops with a comparatively poor equipment can be traced to the fact that they make only one line of tools *but make that well*, instead of dividing their thought and energy among a large variety of work. It is better, both mechanically and financilaly, to build only one tool and build it well than to build a whole shop equipment that is only medium—or worse.

* * *

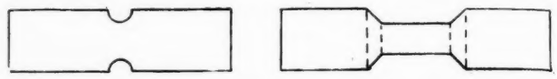
If readers will change the multiplication signs to "plus," in Mr. Cooper's letter on page 123 of last month's paper, they will readily understand the explanation, although such an apparent error should not be misleading.

* See article on square root in the October number.

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

23. C. B., Adamsville, Ohio, asks for information as to test of government inspection of boiler plate. *A.* A test piece, called a "coupon," is taken from each sheet to be used, the piece to be 10 inches long and 2 inches wide. For wrought iron the piece is made like the left-hand figure cut away at the center as shown. For steel the test piece is made like right-hand figure, the center



portion being at least 8 times the width × thickness; the width being 1 inch. Steel plates shall have an ultimate elongation of not less than 20 per cent. in a length of 8 inches, and after being heated to a low cherry red and cooled in water of 82 degrees Fahr. shall be capable of being bent to a curve, whose inner radius is not greater than 1½ times the thickness of the plates.

24. H. J. T., Redondo, Cal., asks: 1. What is the use of having springs over the valves in the water end of a pump? *A.* They are used to close the valves more quickly than would be the case without them. They are not as necessary in slow running pumps as the valves have more time to close themselves, but in fast running pumps they are considered a necessity. Practically the same considerations apply to a plunger pump. Their use can sometimes be avoided by reducing the lift of the valves, and this is often resorted to on fast running pumps to stop the pounding of the valves.

25. C. B. C., Peterboro, Ont. Your request for the illustration of taper turning tools will probably be complied with in the next issue.

26. C. A., Cincinnati, Ohio, asks: 1. Is there any way to compute the volume of condensation which is evaporated into steam during the expansion period and during the exhaust period? If so, will you kindly give that method? Can you give me this in plain English? *A.* I do not know that anything of the kind has been attempted, but should think that by calorimeter tests of both the live steam and the exhaust steam the total amount of re-evaporation might be approximated. There are no simple rules that will apply. F. F. H.

27. B. F., Cincinnati, Ohio, asks several questions in relation to steam and steam boilers. He gives a formula, in part, which he says is used for calculating the heating surface of boilers, and wants to know why it is used. The formula is $(R \times 7) \times$ efficiency × coal consumption equals (presumably) the heating surface. In this formula R = ratio of heating surface to coal consumption. Now, he says, what bothers him is that they generally multiply by 77 or 80 per cent. efficiency, why don't they multiply by 100 per cent.? 2. Now what do they mean, he asks, when they say 1.016, or 1.05 units of heat are absorbed per hour by each square foot of heating surface per one degree of difference of temperature? What method have they for finding the percentage of the various gases passing into the chimney? *A.* The formula to which this correspondent refers as being used for heating surface of boilers is, I should think, one used by some one because it suits his practice. Where is it to be found? Probably more could be told about it by reading the context. The reason 100 per cent. is not used as the efficiency is because no such efficiency is possible. From 15 to 25 per cent. of the total heat in the coal is used to create chimney draught, to say nothing of little losses here and there. The efficiency of a boiler is the percentage of the total heat of the coal that is utilized for making steam, and 80 per cent. is a remarkably high efficiency, seldom or never reached in a steam boiler. A heat unit is a definite thing, as much as a yard or a pound is. The heat unit is used to measure the quantity of heat, and not temperature. In order that heat may be transmitted through metal plates, whatever is at one side must be hotter than than which is at the other side. From what you write it seems that some one says that 1.016 to 1.5 heat units will be transmitted through each square foot of a plate per hour for each change of one degree of temperature between the two sides. The quality of the gases passing up the chimney is determined by analysis. F. F. H.

28. W. G. C., Montclair, N. J., says: We are casting pieces of

bronze pipe, 3 feet long, 3 inches outside diameter and 2⅜ inches inside diameter. The moulds are carefully made, dried in an oven and baked. The core has a very large vent. The mixture is 8 pounds of copper to 1 pound phosphor tin. We are troubled with blow holes about the size of a small pea, which seem to be caused by gas, as there is no sand in them. The moulds are poured vertically, *A*. Phosphor bronze, unlike most other bronzes, remains very liquid until almost the moment of setting, it is, therefore, more readily affected by hard and impenetrable sand mixtures, which, owing to their lack of porosity, cannot receive the surface gases that are generated while the mould is filling. There is more or less commotion as the metal rises and much of the gas then made is held imprisoned in the body of metal. Especially is this liable to occur in thin castings, the heavier ones favor the escape of these gases by reason of the metal remaining in a fluid state for a longer period. Steam from mould or core will effect the metal in a similar manner; this will naturally suggest the importance of everything connected with all such moulds being thoroughly dry before casting. Moulds and cores for the class of castings under consideration should be one-half pure, coarse silica sand, and the other half dried loam, as described on page 125 "The Iron Founder," or something that will be equivalent to it, and the whole brought to the proper consistency for moulding with, by molasses or glue water in preference to either clay or flour. This makes a very porous facing and core-sand, into which the gases can easily penetrate and find their way to the vents. The metal's temperature and the pressure exerted upon it while in a fluid state are important factors in this question. Cast no hotter than is absolutely necessary for producing a clean casting free from seams, this will tend to prevent segregation. When practicable, the metal should be forced from the bottom upwards, and care should be taken for freeing the mould of gases generated while pouring. See "Encyclopædia of Founding," page 71, also article "Honeycombing," page 208 of the same work in relation to pressure for eliminating blow-holes. In this case it will be well if the head pressure could be increased *ad. lib.*, carrying the mould some distance beyond the length of casting desired. This riser-head should be left open to the atmosphere and extended as high as the top of runner basin. By this means the gases would find an easy exit in that direction and the casting would receive every possible benefit from the added pressure. If the riser head be objected to, then continue the increased pressure at the pouring basin, contrive a free escape for gas at the top, and introduce the metal somewhat after the manner described for guns, etc., on pages 265, 266 "The Iron Founder," where it will be seen how, by spreading the runners, a vertical mould may be filled with metal at an even temperature at all points, a very important operation and something to be desired in the absence of any riser-head.

S. B.

* * *

THE FIRST PRINCIPLES OF MECHANICS.—4.

LESTER G. FRENCH.

MOMENTS.

The tendency of a force acting upon a body is in general to produce either a motion of translation (that is, to cause every part of the body to move in a straight line), or to produce a motion of rotation. A *moment*, in mechanics, is the measure of the turning effect of a force which tends to produce rotation. For example, suppose a force to act upon a body which is supported by a pivot. Unless the line of action of the force happens to pass through the pivot, the body will tend to rotate. Its tendency to rotate, moreover, will depend upon two things: (1) upon the magnitude of the force acting, and (2) upon the distance of the force from the pivot, *measured along a line at right angles to the line of action of the force*. These two factors taken together always determine the turning effect, and their product is called the *moment* of the force.

To illustrate further, suppose the wrench shown in Fig. 17 to be in position No. 1, and that a person grasps it at point F and pulls in the direction of the arrow along the line C D, first with a force of 25 pounds, and then with a force of 50 pounds. The bolt O acts as a pivot, and the tendency to turn the wrench and nut about it is twice as great in the latter as in the former case, because the first factor, namely, the magnitude of the force, has been increased two-fold. Again, grasping the wrench at E and pulling along the line A B, its effectiveness would be lessened, for the reason that the second factor, or the distance *e*, measured from the point O and at right angles to the line A B, is less than the distance *f* measured at right angles to line C D.

Finally, suppose the wrench to be in position No. 2, to be grasped at the end at F, and to be pulled with a force of 50 pounds in the direction of line I K, parallel to lines A B and C D. Here the wrench is held at the same point and pulled with the same force as at first, but we know from experience that, so far as turning the nut is concerned, the wrench will be far less effective than when in position No. 1. The explanation is found in the fact that the *effective* distance of the force from O is the distance *h*, measured at right angles to the line I K, along which

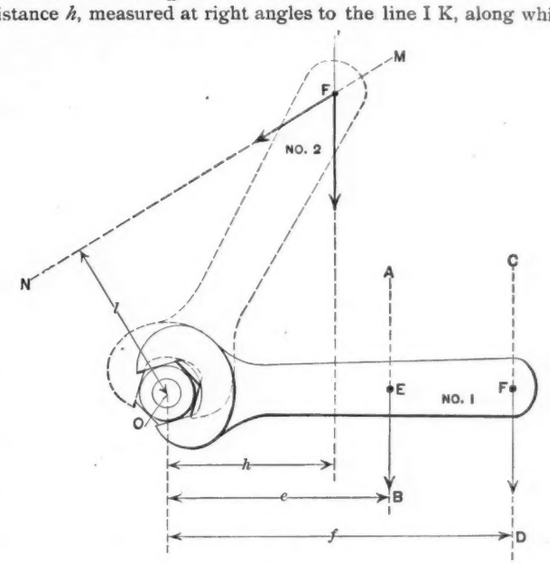


FIG. 17.

the force is supposed to act, and that this distance is less than either *e* or *f*.

From this illustration we see that the moment of a force is numerically equal to the product of the magnitude of the force and the perpendicular distance from the axis, or pivot, to the line of action of the force. To find the moment of a force, therefore, (1) determine the location of the axis about which the body is supposed to turn; (2) draw an indefinite line representing the line of action of the force; (3) multiply the force by the perpendicular distance from the axis to the line.

This perpendicular distance, as *h*, *e*, or *f* in Fig. 17, is called the *lever arm* of the moment, and the axis or pivot the *center of rotation*. If the force is taken in pounds and the lever arm in inches, the result will be in *inch-pounds*, while if the foot were used as the unit of length, the result would be in *foot-pounds*. The term foot-pound, however, has here a very different meaning from that which has been given to it before. In this case it is the unit of rotative effect, and in the other the unit of work, or the work done in raising one pound one foot high. The two should not be confused.

In Fig. 17, if the pull along C D should be 50 pounds and the distance *f* 15 inches, the moment of the force would be 15×50= 750 inch-pounds, or

$$\frac{15\times 50}{12} = 62\tfrac{1}{2}$$

foot-pounds. If the wrench in position No. 2 should be pulled in the direction of the arrow along the line M N, the moment would be the product of the force and the lever arm *l*. When a force tends to produce right-hand rotation, or rotation in the direction in which the hands of a watch move, its moment is said to be *positive*, and *negative* when the rotation tends in the opposite direction.

THE REACTION OF THE PIVOT.

If a block of wood be set on end on a smooth sheet of ice, as in Fig. 18, and a horizontal force be steadily applied at its upper end, it will simply slide along the surface; but let the block be placed upon a rougher surface, and the result will be that it will overturn or rotate about the point O, which acts as a pivot. In both cases the frictional resistance F on the lower end of the block is a force acting in a direction opposite to P. On the ice the force F is smaller than the force P, but on the rougher surface it becomes exactly equal to it; for, if F should be smaller than P, instead of equal to it, the block would not overturn, but would

move to the left as it did when resting upon the ice. Similarly, whenever rotary motion of any body occurs, there must be at least two equal and opposite forces not in the same straight line. This principle is universal.

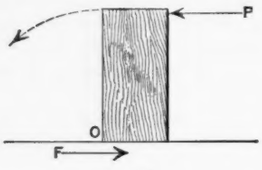


FIG. 18.

In Fig. 17, for example, the bolt must re-act with a force equal and opposite to that applied to the handle of the wrench. There is a reaction at the shaft and bearing of a gear wheel or pulley, which is equal and opposite to the force applied by the driving gear or belt.

THE PRINCIPLE OF MOMENTS.

When two or more forces act upon a rigid body and tend to turn it about an axis, then, for equilibrium to exist, the sum of the moments of the forces which tend to turn the body in one direction must be equal to the sum of the moments of those which tend to turn it in the opposite direction about the same axis.

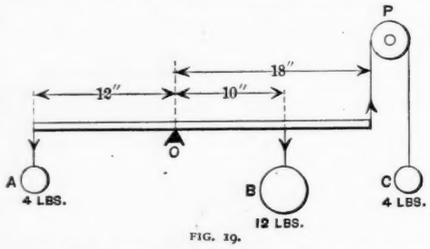


FIG. 19.

In Fig. 19 a lever 30 inches long is pivoted at the fulcrum O. At the right, and 10 inches from O is a weight, B, of 12 pounds, tending to turn the bar in a right-hand direction about its fulcrum O. At the left end, 12 inches from O, the weight A of 4 pounds tends to turn the bar in a left-hand direction, while weight C, at the other end, 18 inches from O, has a like effect, through the use of the string and pulley P. Taking moments about O, which is the center of rotation, we have:

Moment of B = 10 × 12 = 120 inch-pounds.

Opposed to this are the moments of A and C.

Moments of A = 4 × 12 = 48 inch-pounds.
Moments of C = 4 × 18 = 72 inch-pounds.

Sum of negative moments = 120 inch-pounds.

Hence, the opposing moments are equal, and, if we suppose, for simplicity, that the lever is weightless, it will balance or be in equilibrium. Should weight A be increased, the negative moments would be greater and the lever would turn to the left, while if B should be increased, or its distance from O be made greater, the lever would turn to the right. In the next chapter some additional examples of levers will be taken up.

Another application of the principle of moments is given in Fig. 20. A beam of uniform cross-section, weighing 200 pounds, rests upon two supports, R and R′, which are 12 feet apart. The weight of the beam is considered to be concentrated at its center of gravity G, at a distance of 6 feet from each support. A weight of 50 pounds is placed upon the beam at a distance of 9 feet from the right-hand support, R′. Required, the portion of the total weight borne by each support.

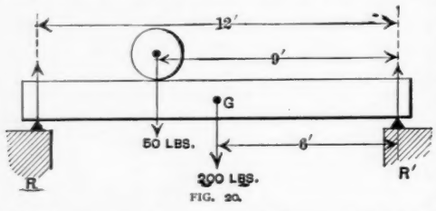


FIG. 20.

Before proceeding, it should be explained that the two supports re-act, or push upward, with a force equal to the downward pressure of the beam. To make this clear, suppose two men to take hold of the beam, one at each end, and that the supports be withdrawn. Then, in order to hold the beam in position, the two men must together lift or *pull upward* an amount equal to the weight of the beam and its load, or 250 pounds. Placing the supports in position again, and resting the beam upon them, does not change the conditions. The supports must re-act upwards just as the men had to *pull* up. The weight of the beam acts downward, and the supports re-act by an equal amount. This is an extension of the principle of the reaction of the pivot mentioned above.

Now, to solve the problem, assume the beam to be pivoted at one support, say at R′. The forces or weights of 50 pounds and 200 pounds tend to rotate the beam in a left-hand direction about this point, while the reaction of R in an upward direction tends to give it a right-hand rotation. As the beam is balanced and has no tendency to rotate, it is in equilibrium and the opposing moments of these forces must balance. Hence, taking moments,

9 × 50 = 450 foot-pounds.
6 × 200 = 1,200 foot-pounds.

Sum of negative moments = 1,650 foot-pounds.

Letting R represent the reaction of the support,

Moment of R = R × 12 foot-pounds.

By the principle of moments, R × 12 = 1,650. That is, if R, the quantity which we wish to obtain, be multiplied by 12, the result will be 1,650. Hence, to obtain R, divide 1,650 by 12, whence R = 137½ pounds, which is also the weight of that end of the beam. (See explanation of Example 1, November number.) As the total load is 250 pounds, the weight of the other end must be 250−137½ = 112½ pounds.

EXERCISE 4.

1. (*a*) A force of 20 pounds acts perpendicularly to an arm 8 feet long. (*a*) Find its moment. (*b*) What would be the moment if the force should act at an angle of 45° with the arm?

2. In Fig. 19, substitute for the 12 inches a length of 14 inches and for the 12 pounds a weight of 14 pounds. Will the lever then be in equilibrium, and if not, which way will it turn?

3. In Fig. 20, find the reactions of the supports, by assuming that the support R is the center of moments.

4. In the same figure, suppose that the weight be removed and that a force of 50 pounds acts upon the beam at an angle of 45° at the same point. How would you then find the reactions?

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

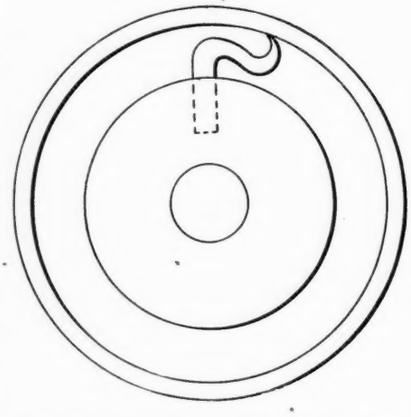
A TOOL FOR TAKING A FINISHING CUT IN A CYLINDER.

The sketch below shows the shape of a tool to use when taking a finishing cut in a cylinder.

It will be found a cheap and good tool in shops where they do not make a specialty of making cylinders, and where they do not have the proper boring bars. You can take any kind of a boring bar and fasten a head on, drill a hole in the head, slip the tool in and fasten it with a set screw; or if the bore of the cylinder is small, drill a hole in the bar and fasten the tool in any way you choose.

I have had machinists say to me that they had never seen a spring tool like that before. Well, I would not call it a spring tool, but would call it a lead tool, for it was upon that principle that I made it, for you have the pulling part in advance of the cutting edge.

A straight tool will work better if you have the dog or carrier in advance of the cutting edge. You can pull a cart with greater ease and steadiness than you can push it.



This tool can be dressed to ⅜ thick and ¾ or ⅞ wide, and bent to 15° or more like sketch, but nothing less, for if you do it will chatter. Grind the tool in a grinding machine, or put an emery wheel in a lathe and fasten the tool in the tool post. Then take an oil-stone and rub the ends so that the traverse marks will not show in the cylinder. Speed the lathe down somewhat slower than what you use in taking the roughing cut, and use 3½ or 4 thread traverse feed.

In tempering the tool it should be dipped and not drawn, and by taking good care of the tool and not letting it hit anything, it will hold a sharp edge for a long time.

It will do good work in brass if you have plenty of clearance.

If it shows traverse marks in starting the cut in the cylinder, do not take it out and regrind it, but tap it one way or the other, and you will by practice get it to do good work.

I have taken a finishing cut in a pump cylinder 10×36 inches in thirty minutes. This may not be anything extra for a pump factory, but in a shop where they do not have the right kind of boring bars or tools I think it is very good time.

If the job wants to be extra smooth and true, take the second cut, though without changing the tool. C. E. PREECE.

So. Chicago, Ill.

MORE HIGH CHIMNEYS.

In the September number of your paper there is an interesting article giving a list of the "Tallest Chimneys on Earth." Of course in an article which covers such a large territory, omissions are liable to occur. What we of the West consider the tallest chimney in this country, we have right here in Denver, at the works of the Omaha & Grant Smelting and Refining Co. The chimney is 353 feet high, and was built in 1892 from the design of Wm. M. Scanlon.

There is a sectional view and elevation of this large chimney in "Helios," the excellent book on steam, gotten out by the Heine Safety Boiler Co., of St. Louis, on page 93. The dimensions there give 350 feet, which is incorrect, as the height is 353 feet.

THOMAS L. WILKINSON.

Allow me to add two more to your recent list of high chimneys, those of the Johnson Co., Lorain, O., which are over 180 feet, just how much over I cannot state. R. W. MOSES.

Allegheny, Pa.

The table recently given was very incomplete. There is a 300 foot chimney at Rhodes near Middleton, in Lancashire, one of 290 feet at Heaton Mersey, Lancashire, and many score over 150 and 200 feet, all over England, especially in Lancashire, where a factory chimney is supposed to be 200 feet, and many are higher than this. W. H. BOOTH.

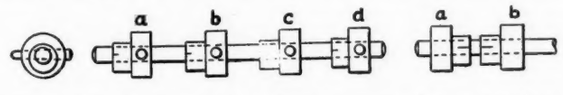
OVERCOMING A SNAG.

The problem of securing a number of eccentric bushings in line on a shaft so that the eccentric part would line up with a number of holes (bored in line), came up in shop practice, of which I will give a solution, as it may prove interesting and useful to others, The bushings are to be secured to the shaft with taper pins.

First, a line was drawn on shaft by laying it along a slot in a planer table and scribing a line lengthwise. Then two bushings were placed on the shaft opposite each other as at *a* and *b*. The eccentric parts were then placed flush together by using a short scale as a straight edge, a line was then drawn anywhere on the eccentric parts of *a* and *b*. The other bushings (*c* and *d*) were then marked from *a* in same position. If bushing *a* was an extra one and did not require to go in same position as the others, this would be all the marking required except to bring down the lines to hole with center square if required.

But if bushing *a* is to be used with the others in same relative position, then another mark would be required for it to line up with the others when reversed, unless the first line had been made exactly over the center of either extremity of the throw.

We could take any two which have been already marked and place them opposite each other as in *a* and *b* and make a short



temporary mark on the one taking the same relative position of bushing *a*, the mark being drawn from the line on opposite bushing. We then place *a* in the same relative position it is to occupy on shaft (with the other bushings) and mark it from the temporary mark on its opposite bushing. There will then be two marks on bushing *a*, the second, of course, would be the one to line up with. The bushings were then drilled and reamed for pins in a drill press, the bushings placed in V-blocks and clamped by a strap on the shaft. JOHN T. GIDDINGS.

Providence, R. I.

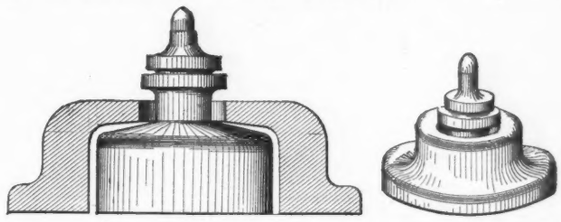
ABOUT THAT "BELL CHUCK."

In your November issue, under the heading "Bell Chucks," R. G. describes a method of fastening certain pieces to the spindle of the lathe. The scheme seems to be a good one, but he fails to describe how the ring B is tightly forced on to nut A, which is shown to be smallest towards the shoulder of the spindle. It is apparent that loosening of the nut A, by driving back ring B, would be a very quick operation, and I wish to know if he has an equally quick method for forcing B tightly onto A.

Winsted, Conn. GEO. B. WOODRUFF.

INK-BOTTLE HOLDER FOR DRAFTSMEN.

Draftsmen who use adjustable tables and prepared inks will no doubt have found out to their sorrow the ease with which an ink-bottle will roll over and deposit its contents upon a drawing, with perhaps several days' work upon it. The necessity of having the ink handy, and yet not spilling it, led me to make the following holder, shown in the accompanying sketches.



When not in use over the ink-bottle, it makes a handy paper-weight. I have shown it in connection with a bottle such as contains Higgins' American India ink, as I am at present and have been accustomed to using it; but of course it could be varied to suit other shapes and sizes of bottles, and can be made of cast iron, or brass, or even lead; if wanted to look fancy, can be nickeled or silver-plated. ERNEST J. LEES.

Rockford, Ill.

ABOUT HEAT AND COMBUSTION.

Mr. Wm. O. Webber, in October number of your paper, speaking of impact of heat, says he "don't know why," and then illustrates from laws of motion governing gases, etc.

Is it not that he dropped into the error temporarily of treating heat as matter instead of a condition of matter, and is not his query solved by the consideration of another law, to wit, that gases, etc., pass quickest where there are no angles or obstructions, and therefore that the *heated gases* are held longer by the impact than the straight shoot, and deliver a larger proportion of their temperature heat to the metal and thence to the water?

There is a story that Sir Isaac Newton ordered a carpenter to cut in a door two holes, a large one for the cat and a small one for the kitten; so even if I am right, Mr. Webber is in good company. FIREMAN.

ABOUT PIECE WORK.

From time to time I have noticed various articles on the subject of "piece-work" in machine shops and it is unpleasant to note the disposition of some superintendents in this matter. I have a plan of my own which works very satisfactorily for the men and the company.

The plant of which I am in charge does not manufacture machinery for the market, but have quite a force of tool makers and machinists for the construction of their own tools and special machinery. There are seldom two jobs alike, so that a scale of prices would be impossible. For instance, there are always new dies and punches to make for cutting brass and some of them are quite intricate. To set a piece price on a new punch and die, I proceed thus: I call in my assistant, who, as well as myself, has worked a number of years at tool making. Together we decide upon the best way to construct the tool. Then each takes a blank pad of paper and sets down every operation necessary for the construction of the tool and opposite each item the time which each thinks it would take him to do the work. Then, and not until then, we compare results. As a rule we will not be more than a day or two apart on a tool which would take say three weeks to build. Usually we split the difference and calling thirty cents per hour a fair price, we arrive at a price which ought to be fair since it is what two different men would be willing to do the work for. I also give a sample of piece to be pressed to the man who is to do the job, and he makes his estimates. We compare notes and his price is usually—not always—$10.00 or $15.00 higher than mine. Nearly always I "meet him half way" and as a result the man gets a lively move on him and makes $3.50 to $4.00 per day, while the company gets the tools a good deal cheaper than if made elsewhere and the job is done and out of the way sooner, making

a much smaller percentage added for shop expenses. In this way both sides are satisfied, for the men understand they are not going to be cut if they make a "good thing." A man is welcome to all he can get out of the job if he does it at a price which seems to me to be reasonable and considerable less than what I could get the same work for outside. G. B. W.

PROPORTION—INVERSE AND DIRECT.

It seems as though the answer to question No. 22 in the December issue might be made a little plainer to those who have not "delved deeply" into mathematics, and would suggest the following explanation:

A. To get at the meaning of the expression "inversely proportional to the square of the distance," let us first consider a simple *direct* proportion: If we travel a certain distance on a railroad train and pay a certain sum for every mile travelled, then whatever we pay for the ride is in direct proportion to the number of miles travelled; for instance, one mile, two cents; two miles, four cents: that is, if we travel twice as many miles we pay twice as many cents, and so on.

Inversely proportional is exactly the reverse (or inverse) of this, and it is evident in the case of the thermometer, that the *greater* the distance from the source of the heat the *less* number of degrees of heat it would register.

If the thermometer registered 40 degrees at 10 feet, 20 degrees at 20 feet, 10 degrees at 40 feet, etc., this would be *inversely* proportional to the distance, but if the information in the Encyclopædic Dictionary is correct, instead of being inversely proportional to the distance, it is inversely proportional to the *square* of the distance: that is, the number representing the distance multiplied by itself, so that the problem comes out as follows: $10 \times 10 = 100$ and $15 \times 15 = 225$. Then whatever relation 225 bears to 100, 40 degrees will also bear to the answer sought, which we find to be 17.7 degrees very nearly.

This is calculated by the rules for simple proportion to be found in any school arithmetic, which we have not the space to reproduce here. W. L. CHENEY.

INTEREST ON STOCK IN HAND.

On page 66 of November, 1895, number of your paper,

Interest on cost of	11 pieces	1 month	.0327
" " " "	10 "	2 months	.0595
" " " "	9 "	3 "	.0803
" " " "	8 "	4 "	.0952
" " " "	7 "	5 "	.1041
" " " "	6 "	6 "	.1071
" " " "	5 "	7 "	.1041
" " " "	4 "	8 "	.0952
" " " "	3 "	9 "	.0803
" " " "	2 "	10 "	.0595
" " " "	1 "	11 "	.0327
			.8507

would seem more nearly correct if it read:

Interest on cost of	11 pieces	1st, month	.0327
" " " "	10 "	2d. "	.0297
" " " "	9 "	3d. "	.0268
" " " "	8 "	4th. "	.0238
" " " "	7 "	5th. "	.0208
" " " "	6 "	6th. "	.0178
" " " "	5 "	7th. "	.0149
" " " "	4 "	8th. "	.0119
" " " "	3 "	9th. "	.0089
" " " "	2 "	10th. "	.0059
" " " "	1 piece	11th. "	.0030
			.1962

Or you might put it: Interest on the cost of eleven pieces for a mean average time of six months $6.53, for six months at 6 per cent. per annum = $0.196.

Janesville, Wis. J. D. RIGGS.

PATTERN MAKING AT THE FERRACUTE MACHINE CO.

In your article in the December issue regarding our system of pattern-making, in the first sentence, you speak of our coloring cored surfaces black, whereas the fact is all surfaces representing the future castings are black, and those representing the core, red. The mistake apparently arose from an improper arranging of the sentences, as the first one should terminate with the word "patterns," the remainder of it forming a part of the second sentence.

Bridgeton, N. J. OBERLIN SMITH, Pres't.,
Ferracute Machine Co.

* * *

As we go to press the breaking of a large steam pipe on the new American liner St. Paul is reported. Nine men were killed and several others badly hurt. While little definite information can be obtained, it appears to have been an elbow in one of the main pipes and some accounts say it was an iron casting. It is variously attributed to defective casting, water hammer and insufficient allowance for expansion. It seems as though such accidents were largely preventable if proper attention is given to the piping.

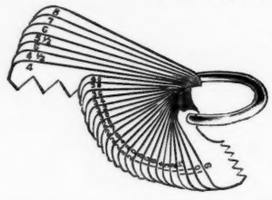
* * *

THE Dixon Crucible Company send us their customary useful Christmas remembrance, a box of their fine pencils, which are held in high esteem by all journalists.

* * *

A NEW THREAD GAGE.

THE STANDARD TOOL CO., Athol, Mass., have just put on the market a new tool for machinists, in the shape of a key ring thread gage, which is illustrated herewith. It consists of twenty-nine gages on a key-ring, for as many pitches of thread, the range being from 4 to 40 threads to the inch. It will be appreciated by machinists and others who have threads to cut or measure.



* * *

SPRING GARDEN INSTITUTE MECHANICAL HANDIWORK SCHOOLS.

Referring to the statement of Mr. Outerbridge in the December issue of the *Engineering Magazine*, that the mechanical handiwork schools of the Spring Garden Institute were established (soon after the famous Russian exhibit at the Centennial Exhibition) under the supervision of Lieut. Crawford, of the navy, Mr. Addison B. Burk, president of the institute in question, writes that they were established in the fall of 1879 by Dr. Robert Grimshaw; that the first class was organized January 26, 1880, and that Lieut. Crawford was detailed to the Institute in the fall of 1882 and reorganized the classes.

* * *

BUSINESS.

NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD. FOR FURTHER PARTICULARS, ADDRESS THIS OFFICE.

If price is low enough, design simple and work accurate, a party could find a place for about 80 small electric motors to develop say $\frac{1}{100}$ (one-hundreth) horse power at 2,500 turns. He also wants some small articles to manufacture in well equipped German establishment, now making needles, spiral wire bed-springs and other articles from wire.

Andrew F. Bush, Ballston Spa, N. Y., wants a second-hand governor, Waters, Judson or Porter Allen make.

* * *

THERE IS ONLY ONE GOOD WAY

To reach the Cotton States and International Exposition, Atlanta, Ga., and that is via the Southern Railway, "Piedmont Air Line." This has been fully demonstrated within the past four weeks. To meet the demand of the traveling public, the Southern Railway has been running its vestibuled limited trains in two and three sections. Commencing Sunday, October 6, a third limited train was put on, called the Exposition Flyer, leaving New York 11 o'clock A. M., reaching Atlanta following morning at 10 o'clock. The patronage of this train has been far beyond expectation, and if it continues to increase as it has done in the past week, it will require two sections to accommodate the travel. The Southern Railway enjoys terminal facilities at Atlanta and, in fact, in nearly every Southern city of importance, that no other line has, consequently are prepared to give the traveling public better facilities and accommodations.

* * *

MANUFACTURING NOTES.

THE evening classes at the Young Men's Institute, 222 Bowery, report a large enrollment this season. One of the most popular classes is that in steam engineering. The enrollment in this class includes workers from all fields of the practical applications of steam, viz.: Fireman, engineers, machinists, etc. They are taught the fundamental principles of the science and also its latest developments. By means of text books, lectures and experiments, a comprehensive view is taken of the whole subject. Other subjects taught are the commercial branches, arithmetic, book-keeping, shorthand, English grammer and technical branches. Carriage drafting, architectural drawing, mechanical drawing, freehand drawing. Some of these require a two and some a three-year course. A new term will begin January 2, 1896. Young men between the ages of 17 and 35 are allowed to enroll at any time.

MESSRS. DRESES, MUELLER & CO. is the name of a new firm just formed and located at Cincinnati, O., for the purpose of manufacturing a line of machine tools. They have built a new shop of ample dimensions and equipped it with a line of the latest improved machinery. They expect to work about fifty men at present, and increase their force at an early date. Mr. Henry Dreses has been chief designer and draftsman for the Lodge & Davis Machine Tool Co. for over twelve years, having designed much of the machinery which they manufacture. Mr. Oscar Mueller was for several years superintendent of the Cincinnati Milling Machine Co., and has recently been building a line of shapers, etc., for the Lodge & Davis Machine Tool Co., and has a splendid reputation as a mechanic. The new firm will start in with a complete line of improved screw machines, and have made arrange-

ments with Messrs. Dawson & Goodwin, of Chicago, to sell their entire output. Considering the experience both members of the firm have had, they should certainly be successful in their new enterprise. Full information regarding the machines built by them can be obtained by writing Dawson & Goodwin, No. 57 South Canal street, Chicago.

THE LODGE & DAVIS MACHINE TOOL CO., of Cincinnati, O., is now working 400 men fourteen hours per day, and are making some extentensive additions to enable them to handle their increasing business. They are now excavating for the purpose of putting a basement under their entire plant, which will enable them to remove cutting-off machines, grinders, surplus steel, castings, etc., from the upper floors, and thus provide many hundred feet of valuable space, which will be sufficient room for the addition of such machinery as may be required for the supplying of their orders. The demand from bicycle factories and the picking up of the trade in all lines generally, has occasioned these additions.

THE TAYLOR-RICE ENGINEERING CO., formerly of Wilmington, Del., have moved their plant to Gloucester City, N. J., and announce that their main office is at 119 South 4th street, Philadelphia, Pa.

THE GEORGE BURNHAM CO., 15 Hermon street, Worcester, Mass., have purchased the planer chuck business of G. W. Jordan, and will manufacture his line in addition to their well known drills.

* * *

FRESH FROM THE PRESS.

THE UNIVERSITY OF MINNESOTA has issued a comprehensive prospectus of their course in locomotive engineering, which is to be under the direction of Prof. H. Wade Hibbard, whose work in practical railroading is well known, having been connected with the Rhode Island Locomotive Works, the Pennsylvania R. R., and the Lehigh Valley, in responsible positions. We cannot enumerate the different features mentioned in the prospectus, but it covers the ground very thoroughly, and will ensure the student a thorough course of instruction in a branch which is one of the important factors of our civilization.

THE KNOWLES PUMP CO., of Liberty street, New York City, have also issued a new calendar of large size, which contains a fine picture of Diana as a center piece, surrounded with a frame of Knowles' pumps in great variety.

THE HILLES & JONES CO., Wilmington, Del., has issued another catalogue (L), which, like the last, is pretty sure to attract attention, and the combination of colors are much more pleasing to the eye. It illustrates the special line of machine tools made by this concern for working iron and steel plates, bars and structural shapes. The engravings are nearly all half-tones, and are good examples of this style of reproductive art.

MR. C. M. GIDDINGS, Rockford, Ill., sends us a neat folio of blue prints bound in flexible covers, which includes sample sheets of prints issued by him in complete sets, giving details of almost any size and kind of engine desired. There is a full line of Corliss and automatic engines, simple and compound, and the plans given indicate that careful attention is given to details. The prices are reasonable, being $5.00 per set, which contains from twenty to twenty-five sheets, and it would seem as though a student in machine design could obtain considerable information from these, as they give the actual practice of a competent engineer.

LANDIS BROTHERS, Waynesboro, Pa., have issued a catalog of their grinder, which is also a well written and very instructive treatise on its construction and use. The machinist who wishes to keep abreast of the times will endeavor to acquaint himself with the construction and operation of the new and improved machines, and this affords him ample opportunity at a slight expense. Superintendents and foremen will probably learn of new uses to which the grinder can be put, and thus add to its economical production in their shop, and many will probably be made aware that they need one of these machines immediately.

THE MASTER CAR AND LOCOMOTIVE PAINTERS ASSOCIATION favor us with the report of their twenty-sixth annual convention, held in Cincinnati, O., September 11, 12 and 13. It contains over 100 pages, several good half-tones of the officers, and is well bound, being published for the association by the Railroad Car Journal, of this city.

THE WEIR FROG CO., Cincinnati, O., have issued Catalog No. 4, under date of 1896, illustrating their frogs, switches, crossings, etc., in great profusion. It contains 273 pages, is well printed and very convenient for reference. There is a large amount of useful information concerning curves and switches, and many valuable tables for engineers and road men.

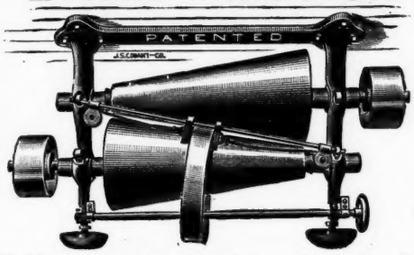
THE NEW YORK CENTRAL AND HUDSON RIVER R. R. has issued a bicycle ticket for wheelmen, so as to save them the annoyance of signing releases, etc. These are in duplicate, one part being attached to wheel, the other being retained by owner for identification. The minimum charge is 15 cents, with a maximum of $1.00, which carries the wheel from New York to Buffalo, a distance of 440 miles. This also applies to baby carriages, which may strike some of the super-sensitive wheelmen as a reflection on their favorite steed, but the rulings seem to fairly apply to both as regards handling in the cars.

THE MATTHEWS-NORTHRUP CO., New York and Buffalo, send us their Daily Reminder, a small and compact calender, diary and daily memorandum, combined in one book of handy size for the vest pocket.

ROBERT POOLE & SON CO., Baltimore, Md., have issued a very neat calendar for the coming year. It is a heavy card, 8 1-4 by 11 1-4 inches, with beveled gilt edge, and contains several views of their works as well as some of their products. The engraving and printing are both excellent, and the calendar is pretty sure to be preserved.

"CHAIN BLOCKS" is the title of a very interesting pamphlet just issued by the Yale & Touwe Manufacturing Co., Stamford, Conn. On the inside of its front cover is a graphical comparison of the efficiency of various blocks from tests made by Prof. R. H. Thurston. The Yale-Weston triplex spur gear block leads with an efficiency of 79.5 per cent. All mechanics, and especially those in charge of shops, should become familiar with these chain blocks, as the economical handling of material is an important item and it should be remembered that it is no more economical to work men at a low rate of efficiency, than it is in the case of machines. Efficient and reliable hoists are a valuable addition to any shop.

EVANS FRICTION CONE PULLEYS.



FORTY-SEVEN different patterns, transmitting from ONE to FORTY horse power, changing the speed of all kinds of machinery while running. Thousands of sets in use.

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G. F. EVANS, PROPRIETOR,
85 WATER ST., BOSTON, MASS.

The following is a partial list of Manufacturers who have Evans Friction Cone Pulleys in operation, transmitting from One to Forty Horse Power:

JOHN & JAMES DOBSON, Philadelphia, Pa.
34 Sets Cone Pulleys, 2 H. P.
NEW YORK BISCUIT COMPANY, New York.
87 Sets Cone Pulleys, 5 H. P.
ALBERT MITCHELL, England.
12 Sets Cone Pulleys, 6 H. P.
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33 Sets Cone Pulleys, 5 H. P.
STERLING DYEING and BLEACHING CO., Sterling, Ct.
16 Sets Cone Pulleys, 6 H. P.
MR. S. D. WARREN, Cumberland Mills, Me.
8 Sets Cone Pulleys, 40 H. P.
AMERICAN BISCUIT COMPANY.
12 Sets Cone Pulleys, 6 H. P.
WASHBURN & MOEN, Worcester, Mass. Waukegan. Ill.
A large number of all sizes.
NONOTUCK MILLS, Holyoke Mass.
16 Sets Cone Pulleys, 6 H. P.
MERCANTILE CONSTRUCTION CO., Brooklyn, N. Y.
20 Sets Cone Pulleys' 2 H. P.
MASSASOIT PAPER CO., Holyoke, Mass.
2 Sets Cone Pulleys, 40 H. P.
TRENTON IRON COMPANY, Trenton, N. J.
9 Sets Cone Pulleys, 2 to 6 H. P.
TAUNTON COPPER COMPANY, Taunton Mass.
8 Sets Cone Pulleys, 2 to 6 H. P.
CLEVELAND WIRE MILLS, England.
4 Sets Cone Pulleys, 6 H. P.
STINSON BROS. & KURLBAUM, Philadelphia, Pa.
30 Sets Cone Pulleys. 1 H. P.
NATIONAL FOLDING BOX and PAPER CO., New Haven, Ct.
1 Set Cone Pulleys, 40 H. P.
F. W. BIRD, East Walpole, Mass.
2 Sets Cone Pulleys, 40 H. P.
ARNOLD PRINT WORKS, North Adams, Mass.
10 Sets Cone Pulleys, 6 H. P.
MERRIMACK MILLS, Lowell, Mass.
18 Sets Cone Pulleys, 6 H. P.
TROY LAUNDRY MACHINE COMPANY, Chicago, Ill.
19 Sets Cone Pulleys, 2 to 4 H. P.
RICE & COMPANY, Lowell, Mass.
5 Sets Cone Pulleys.
BARBOUR & STOCKWELL, Cambridgeport, Mass.
8 Sets Cone Pulleys, 5 H. P.
ALFRED DOLGE, Dolgeville, N. Y.
A large number of small sizes.

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WANTED foreman for a machine shop in Ohio, doing a jobbing and and machine building business, employing from 10 to 20 men. Must give good reference as to sobriety, character, and ability. State age and experience, and class of work employed on. Address
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Advertising Solicitor.

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PHILADELPHIA, PA.

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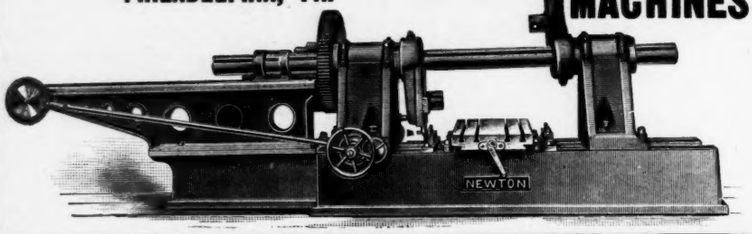

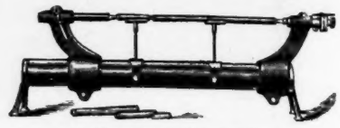

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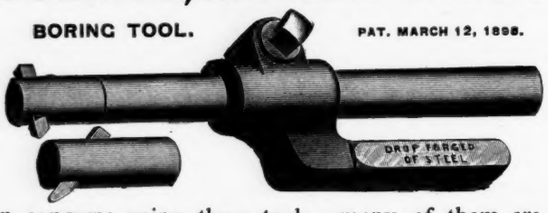
Tempering.

OVER 50,000 NOW IN USE.

SAVES
Tool-Steel,
Time,
Annoyance.

BORING TOOL. PAT. MARCH 12, 1895.



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Woonsocket Mach. & Press Co.,
De LaVergne Ref'g. Mach. Co.,
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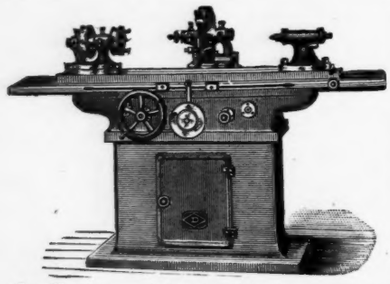

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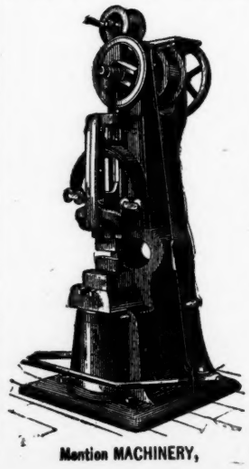

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